Appendix I

Survey Program Technical Memorandum

Wyckoff/Eagle Harbor Superfund Site

Bainbridge Island, WA
September 25, 2017

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Acronyms and Abbreviations

APS	APS Mapping and Surveying
DEM	Digital Elevation Model
EBS	Exposure Barrier System
Ecology	Washington State Department of Ecology
EHOU	Eagle Harbor Operation Unit
EPA	U.S. Environmental Protection Agency
FSP	Field Sampling Plan
MBES	multibeam echo sounder
MCA	Miller Creek Aerial Mapping
MLLW	mean lower low water
NOAA	National Oceanic and Atmospheric Administration
OMMP	Operations, Monitoring, and Maintenance Plan
QAPP	Quality Assurance Project Plan
RGB	Red/Green/Blue
SAIC	Science Applications International Corporation
SBES	single beam echo sounder
SEA	Striplin Environmental Associates
SEE	Science and Engineering for the Environment, LLC
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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1 Introduction

1.1 Purpose

The purpose of this memorandum is to provide an assessment of the physical stability of the Exposure Barrier System (EBS) as outlined in the Year 22 – 2016 Operations, Monitoring, and Maintenance Plan (OMMP). This assessment is supported, in part, by the results of the recently-conducted survey program discussed in this memorandum.

This survey program technical memorandum is an appendix to the 2016 Year 22 Data Monitoring Report. The criteria used to determine whether the EBS is functioning as designed are presented in Sections 4.4.2 and 4.4.3 of the 2016 Year 22 Data Monitoring Report.

1.2 Objective

The objective of this assessment is to determine whether the placed EBS-cover material is physically stable and remains at the target cover thickness of ≥ 2 feet. As first defined in the 2011 OMMP, one foot of erosion is generally considered as an indicator of change. The tools defined in the 2011 and 2016 OMMP include bathymetric and aerial elevation surveys, and through-cover coring. Where one foot or greater of target cover is identified, a subjective review of the area of change is used to evaluate significance.

1.3 Background

Construction of the EBS was completed in 2008. Construction included a beach cover system placed on top of contaminated beach sediments and previously-placed habitat fill in the intertidal zone. The EBS extends from the western edge of the Phase II cap west to the former Wyckoff facility property line, and from the berm above the beach to the south, northward to approximately -10 feet Mean Lower Low Water (MLLW).

The cover system consists of a porous geotextile placed on the original beach, a 1-foot-thick layer of 3-inch cobbles placed on top of the geotextile (from approximately +14 feet to -5 feet MLLW), and a 0.66-meter (2-foot) thick layer of fish habitat fill placed on top of the cobble layer. The subtidal cap extension involved the placement of a 1-meter (3-foot) thick layer of sand and gravel covering the subtidal area (to a depth of -10 feet MLLW) immediately north of West Beach and extending up to the southern edge of the existing Phase 1 cap. In this document, the EBS is defined as including both the cover system and the subtidal cap extension.

Long term physical monitoring focuses on the stability of the coarse sand/gravel cover material over the cobble layer. A post-construction “as built” elevation survey was conducted in 2008 by the U.S. Army Corps of Engineers (USACE). The first post-monitoring event on the EBS, conducted during the Year 16 – 2011 monitoring, included a single beam bathymetry survey, a photogrammetric topographic survey, and a limited number of direct hand-measures of the depth-to-cobble layer. The 2011 elevations were compared to the 2008 “as built” conditions.

An evaluation completed as part of the 2012 Year 17 Monitoring Report found that the EBS may not be physically stable with apparent losses of between 1 and 2 feet of material in the lower intertidal zone, and material gains of 2 feet in the upper intertidal zone. Of the direct-cover measurements, all of the low intertidal sampled stations had cover measurements with ≥1 foot of cover thickness. Four stations in the high intertidal area at the upper edge of the fill area had less than 1 foot of cover material (HDR and SEE 2012).

1.4 Previous Site Elevation Surveys

Hydrographic surveys have been the main monitoring tool for determining the physical stability of the placed caps at the Wyckoff/Eagle Harbor Superfund site since prior to initiation of the Phase 1 cap construction in 1993. Upland elevation surveys were first added to the monitoring program in 2004. A brief list of the EHOU elevation surveys used in pre- and post-construction monitoring is provided below:

- 1993 – 1994 cap construction bathymetric surveys included pre-placement condition surveys synoptic with placement activities, and a post-placement survey. These activities are documented in the 1994 On-Scene Coordinator's Report (EPA and USACE 1994).
- 1995 National Oceanic and Atmospheric Administration (NOAA) navigation bathymetric survey (cited in the 1995 Monitoring Report). As the data quality objectives for the NOAA survey differed from those specified in the 1995 OMMP, those data were only qualitatively used in the 1995 (Year 1) Monitoring Report.
- 1995 U.S. Geological Survey (USGS) Subbottom Sonar Profiling, as referenced in the 1995 Monitoring Report.
- 1997 (Year 3) post-placement bathymetric monitoring was conducted solely in the Phase I cap area (SAIC 1998).
- 1999 (Year 5) bathymetric soundings were collected by USACE of the main basin, entrance of Eagle Harbor, and the nearshore areas, including the former West Dock and Wyckoff property shallow subtidal areas (East Beach, North Shoal, and West Beach) (SEA 2000).
- 2004 (Year 8) hydrographic surveys of the main basin and entrance of Eagle Harbor were conducted by the USACE. The nearshore areas surveyed were the same as those conducted in 1999 (Integral and USACE 2004).
- 2004 (Year 8) surveys were subcontracted to APS Mapping and Surveying (APS) for additional shallow subtidal and intertidal soundings in the Phase II and Phase III cap areas as well as the shallow subtidal and intertidal areas surrounding the Wyckoff facility (Integral and USACE 2004).
- 2004 (Year 8) beach elevation surveys were conducted by APS using differential Global Positioning System and traditional range-azimuth survey techniques. A 7-acre upland area was also surveyed as part of the February 2004 study (Integral and USACE 2004).

- 2005 photogrammetric topographic survey was conducted on 1 September 2005, and a bathymetric survey was conducted 26-27 September 2005. These surveys were merged together to create the 2005 combined detailed elevation model surface cited in the 2011 Year 17 Monitoring Report (HDR and SEE 2012).
- 2008 EBS post-construction (“as-built”) single beam hydrosurvey (HDR and SEE 2012).
- 2010 bathymetric soundings for the entirety of the EHOU were collected by USACE. This included all of the Eagle Harbor Basin, West Beach, North Shoal, and the nearshore area of East Beach (HDR and SEE 2012)
- 2010 on-land elevation survey data were collected using photogrammetric mapping methods by APS. The combined bathymetry and elevation survey data were used to determine areas of erosion and accretion on the EBS (HDR and SEE 2012).

2 Methods

Methods for the site elevation surveys are described in the 2016 Field Sampling Plan (FSP) of the Quality Assurance Project Plan (QAPP), (Appendix B of the primary report to which this appendix is attached). Physical stability measurements outlined in the 2016 OMMP Addendum included a hydrographic survey, aerial image and lidar acquisition, and direct physical measurements of the cover thickness at select locations.

Elevation mapping was led by Miller Creek Aerial Mapping (MCA); the survey team included TerraSond (bathymetric surveys), APS Surveying and Mapping (field surveys), GeoTerra (airborne lidar acquisition), and GPS Surveying (aerial imagery acquisition). Direct field measurements of the EBS cover thickness, conducted by HDR, with Science and Engineering for the Environment, LLC (SEE), the U.S. Environmental Protection Agency (EPA), USACE, and the Washington State Department of Ecology (Ecology), are reported in Section 3.3 of the Year 22 Data Monitoring Report.

Methods for the elevation surveys are briefly discussed in the following sections.

2.1 2017 Bathymetric Surveys

The bathymetric survey was conducted following the methods described in the FSP. One significant change is that Year 22 bathymetric data was collected using both single beam sonar, and also using multibeam sonar. The previous surveys had been conducted with single beam; future bathymetric monitoring at the EHOU will be completed using multibeam. The objective of the concurrent sonar measurements was to document the similarities and differences on shore profiling using the two methods.

Bathymetric data were collected on 11 January 2017 between 12:00 – 16:00 PDT on a rising tide to 11.97 feet MLLW at 15:02 hours. Surveys were conducted from the TerraSond survey vessel *R/V Carta*. A complete description of the methods, survey control points, quality assurance and quality control measures, and data processing, are provided in the TerraSond survey report in Appendix I-1.

The deliverables provided in Appendix I-1 include the following:

- Appendix I-1a. TerraSond Eagle Harbor project report
- Appendix I-1b. ASCII X,Y,Z point files of bathymetric points. Gridded at 1 foot x 1 foot (electronic only)
    - Multibeam files are noted with a MBES
    - Single beam with a SBES.
- Appendix I-1c. Shaded-relief imagery of multibeam data in GEOTIF format (TIF/TFW) (electronic only)

2.2 2017 Beach Elevation Surveys

The orthophoto and lidar surveys were conducted following the methods described in the FSP. Details of both surveys are included in the MCA elevation surveys report (Appendix I-2), but are described briefly here.

The orthophoto of West Beach was collected on 30 January 2017 using a gyro-stabilized Ultracam Falcon digital image sensor mounted in a Cessna 206 StationAir. Imagery was acquired under high overcast conditions to minimize shadows. Orthophotos are provided in Appendix I-2, and include both Red/Green/Blue (RGB) color, and color infrared images.

As a result of a combination of operational difficulties, inclement weather, and a lack of daylight low tide sequences, it was not possible to obtain the lidar until late spring 2017. The lidar data was acquired on 26 May 26 2017 during a single mission. The sensor used was an Optech Galaxy mounted in a Cessna 310 fixed-wing aircraft. The flight plan was designed with a minimum of 50 percent overlap in swath footprint to minimize laser shadowing and data gaps. The lidar data was acquired with a planned nominal density of >8 points per square meter and during a -2.6 feet MLLW tide to ensure significant overlap between the lidar and hydrographic data.

The deliverables provided in Appendix I-2 include the following:

- Appendix I-2a. MCA Orthophoto, Lidar, and Bathymetric Survey Report project report
- Appendix I-2b. RGB and infrared color orthophotos (electronic only)
- Appendix I-2c. Lidar data including (electronic only):
    - All returns
    - Bare earth returns
- Appendix I-2d. Digital Elevation Model (DEM) (electronic only)

2.3 Interpolation Methods

The 2017 elevation and bathymetric data were prepared by MCA and TerraSond. Delivery reports for these datasets are included in Appendix I-1 and I-2. DEMs for each dataset were generated and provided by MCA. One combined lidar and bathymetry DEM was also provided. No interpolation of surface values was performed as these combined datasets provided full coverage of the EBS. HDR reviewed the combined dataset and confirmed multibeam bathymetry data were used and was supplemented by the lidar to provide full coverage of the EBS. HDR also spot checked the merged edge elevation values against the original DEMs.

To compare elevation values between survey data across different years, the ArcGIS Raster Calculator was used to subtract the elevation values of the most recent year's data (i.e., 2017) from the corresponding elevation values of previous years. The resulting output provided values indicating the change in elevation between the two years.

Raster datasets were displayed using 14 manually-defined display classes. Classes were specified at 1-foot intervals, with an additional interval specified at 0.5 and -0.5 feet, respectively to better illustrate small changes in the surface elevations.

Elevation profiles were generated by first creating regularly spaced points at 10-foot intervals along specified transects. Elevation values from the combined elevation dataset for each of the time periods evaluated were transferred to the corresponding transect point using the Extract Values to Points tool. The resulting dataset was imported into Microsoft Excel and charts generated comparing the extracted elevation values between years.

3 Results

3.1 Single vs. Multibeam Bathymetry

The single beam and multibeam data in the Wyckoff/Eagle Harbor Superfund site surveys showed good correlation (Figure I-1). To generate the comparison in Figure I-1, the single beam and multibeam xyz data were brought into AutoCAD Civil 3D 2013. Five profile lines, spaced across the survey from east to west, were drawn in AutoCAD and the single beam versus multibeam surface elevations were compared along these lines. Figure I-1 presents one of those five profiles between the two surveys.

The single beam and multibeam generally found to be within 0.1–0.2 feet of one another. Measurements with the multibeam tend to report lower elevation than the single beam. Based on this relatively tight comparability, coupled with the fact that the sounding data density was significantly higher using multibeam, the multibeam surveys data were subsequently used to make comparisons to the 2009 and 2011 data sets used for comparison to the 2008 "as built" EBS condition, and the 2011 monitoring data.

3.2 Elevation Survey Findings

3.2.1 Elevation Contours

Elevation contours in 1 foot increments within and proximal to the EBS, based on the combined lidar and bathymetric data sets, are shown in Figure 1-2. The boundaries of the EBS extend from approximately +15 feet MLLW to between -12 and -14 feet MLLW. This is consistent with the presentation of the EBS elevations in the 2011 Data Monitoring Report (HDR and SEE 2012). At the west edge of the EBS, formation of a sand spit is evident; the leading edge of this feature is at approximately 0 feet MLLW.

An additional advantage of using the multibeam is the ability to be able to generate shaded relief elevation maps (see Figure I-3). Referred to in the TerraSond report

(Appendix I-1a) as a “sun illuminated imaging,” TerraSond used the software Caris HIPS to create a 3D effect of inserting a shadow onto the multibeam base surface for the georeferenced orthophotograph. Figure I-3 presents the visualization of the subaquatic seafloor.

The sand spit is more clearly seen in the shaded relief elevation map (Figure I-3). The sand spit, not observed in the 2011 survey, is evidence that sand is being mobilized from the EBS, translocated along the shore and depositing onto the spit.

The multibeam data revealed in-water structures that had not been observed or reported in any of the previous surveys. These underwater structures, while off the EBS, are on the Phase I cap (see Figure I-3). Shown in a color relief inset box on Figure I-3, structure numbers 1 through 3 appear to be objects placed on the cap; structure number 4 appears to be sunken logs.

3.2.2 Changes in Elevation - 2008, 2011, and 2017

To evaluate the subtidal cap stability, the results of the 2017 survey program were compared to surveys previously completed in 2008 (post-placement) and 2011. Topographical survey data from the elevations surveys in 2008 and 2011 were combined by USACE for the 2011 Year 17 Monitoring Report into a survey grid; those grid files were provided to HDR. Differences in elevation were determined by subtracting each year’s grid elevations from previous monitoring elevations as follows:

- 2008 to 2011 (Figure I-4)
- 2011 to 2017 (Figure I-5)
- 2008 to 2017 (Figure I-6)

Figure I-4 compares the 2008 post-construction elevations with the elevation survey monitoring completed in 2011.[1] Figure I-4 is the same as Figure 3-5 in the 2011 Year 17 Monitoring Report. The 2011 Year 17 Monitoring Report noted that both erosion and accretion occurred at the EBS between 2008 and 2011. Within the lower intertidal areas, an apparent loss of between 1 foot and 2 feet of cap elevation was identified, while in the high intertidal, gains of up to 2 feet of new material were noted. Comparisons of elevations for beach profile transects for 2008 and 2011 are also shown on xy plots in Figure I-4. In all of those plots, the 2011 elevations are either at or below those measured in 2008. USACE calculated that approximately 5,005 cubic yards of material had been lost from the EBS between construction and 2011.

Figure I-5 compares the 2011 and 2017 monitoring elevation surveys. This comparison suggests that substantive erosion is still occurring in the lower intertidal and subtidal sections of the EBS; between 1 foot and >5 feet of material loss. Of specific note is the high intertidal region between beach transect lines 4+00 and 6+00, where 1 to 3 feet of erosion is indicated. This is the same area of the EBS where the direct cover measurements reported in Section 3.3.2 of the 2017 Data Monitoring Report showed that

[1] The elevation contour color scheme presented in the 2017 legend bar is changed from the scheme used as part of 2011 reporting. The 2011 figures represented elevation losses in shades of blue, and elevation gains in yellows-to-red. For ease of identifying areas of erosion, the color scheme is reversed here: yellows-to-red represent erosion; areas of blue represent accretion.

no (0 feet) cover material remained; the underlying cobble area was visible. It is worth noting that this specific area is proximal to the outflow pipe that channels stormwater from the hill above onto the beach. Other than that specific area, the beach profile transect plots suggest that for the upper intertidal areas little to no elevation change is evident.

Figure I-6 compares the 2008 post-construction ("as-built") elevations with the 2017 elevations. This figure represents the sum of all elevation changes that occurred since construction of the EBS. Accretion of material is shown in the uppermost intertidal areas just below the berm with substantive losses of between -1 and -5 feet over most of the EBS below approximately the +10 foot contour line. This is further evidenced by the xy beach profile transects on Figure I-6; except for those points above +10-foot elevation, the 2017 points are substantively below the 2008 post-construction surface elevations.

3.2.3 EBS Field Cover Measurements

The direct field-cover measurements on the EBS are discussed in Section 3.3.2 of the 2017 Data Monitoring Report, and are briefly represented here to support the physical stability evaluation. The direct hand-measurements of the EBS cover in 2017 show mixed findings (see Figure I-7). Of the 12 measurements made on the EBS during the 2017 monitoring, seven stations had ≥2 feet cover material, two stations were approximately between 1 and 1.5 feet, and three stations had 0 feet of cover material. The area where no cover material was identified is in the upper intertidal area of grid H12; at this location the underlying cobble was visible.

That erosion is occurring is indicated by the fact that the corresponding cover measurements made in 2011 were greater than that observed in 2017 (Figure I-7). This is especially noted at the measurements made in the upper intertidal grid H12 where approximately 1 foot or greater of cover was identified in 2011, whereas in 2017 no cover material was identified and the underlying cobble is directly exposed. Further evidence of erosion was found at the following 2017/2011 paired measurement locations: I12-c2, a 2-foot elevation loss; H12-a2, a 0.65-foot loss; and F12-d1, a 1.6-foot loss.

3.3 EBS Physical Stability Evaluation

The surveys discussed in this technical memorandum were undertaken to determine whether the EBS is physically stable and remaining in place at the target cover thickness. The survey data suggest that the EBS cover material is not physically stable, in some areas has less than the target cover thickness of ≥2 feet, and is below the minimum of 1 foot of fish habitat mix material that may trigger additional actions. Data supporting that finding are those listed below.

2008 to 2017 Elevation Change. Loss of elevation, relative to the 2008 "as-built" survey, is evident across the EBS (Figure I-6). With the exception of the upper intertidal where some accretion appears to have occurred, on average >1 foot of erosion across the EBS is apparent. The four beach profile transects shown on the right column of Figure I-6 demonstrate that the 2017 elevations are less than the 2008 as-built survey elevations. This finding is consistent with 2011 where, for these same four transects, the 2011 elevations were generally less than the 2008 as-built elevations.

Figure I-8 presents a graph that provides a comparison of the erosion/accretion along the four beach transects, comparing the 2008 to 2011 (blue line), 2008 to 2017 (red line), and 2011 to 2017 (green line) survey information. In the graphs, “0” on the y-axis represents the 2008 condition, values below the 0-line represent erosion, and values above the 0-line represent accretion. What is evident on the graph is that erosion is principally occurring in the lower intertidal and subtidal areas of the EBS. These graphs also indicate that most of the changes in elevation occurred in the period post-construction to the 2011 monitoring, but that erosion is still occurring.

Direct Measures. That erosion may still be ongoing is indicated by the fact that the corresponding cover measurements made in 2011 were greater than those observed in 2017 (Figure I-7). This is especially noted at the measurements made in the upper intertidal grid H12, where in 2011 approximately 1 foot or greater of cover was identified, whereas in 2017 no cover was observed and the underlying cobble is directly exposed.

Additional Observation. The observation of the formation of a subtidal sand spit (Figure I-3) at the western edge of the EBS is evidence that cross-shore sorting (erosion) and long-shore transport of the finer sand is occurring.

3.4 Uncertainty Evaluation

That erosion is occurring on the EBS is evident in the lines of evidence cited above. What is uncertain is the degree to which that erosion has occurred across the entire EBS, and the degree to which it is ongoing. Two principal sources of uncertainty exist relating to the evaluation of physical stability of the EBS: (1) completeness and comparability of the data underlying the interpolations for the 2008, 2011, and 2017 surveys, and (2) whether the remaining cover on the EBS as a whole is less than 2 feet in depth.

The first source of uncertainty in this interpretation may be in part due to the differences in the spatial comparability and coverage (completeness) of the data points in the three rounds of surveys. The underlying elevation data for the 2008 and 2011 interpolations were completed by comparing single beam bathymetry and photogrammetry, whereas the 2017 data comparisons used multibeam bathymetry and lidar. The analysis of single beam versus multibeam bathymetry data completed by TerraSond demonstrated the relative comparability of the two measurement methods at the same point (Figure I-1). However, the multibeam data are on a finer spatial resolution, with 5 data points per square foot over the entire survey area, whereas the single beam data are on transects spaced approximately 160 feet apart and data points spacing slightly over 1 foot.

Data coverage in at least the 2008 and 2011 surveys was incomplete for much of the intertidal zone on the EBS. The 2008 as-built survey data are based solely on hydrosurvey data; no corresponding photogrammetry data was collected to provide upper intertidal elevations. In 2011, the bathymetric survey only went shoreward up to between -0.4 feet MLLW and -5.9 feet MLLW. The 2011 aerial photogrammetry data points were sparse on the EBS and only extended to +10 feet MLLW (see Figures 2-1 and 2-2 in the 2011 Year 17 Monitoring Report). By contrast, the 2017 lidar and bathymetry data overlap is down to -2.6 feet MLLW on the lidar and up to +4 feet MLLW for the bathymetry data.

The second source of uncertainty on the physical stability of the EBS rests with the limited number of direct-measurements of cover thickness. The complete erosion of the EBS cover in the upper intertidal areas of grid H12 (see Figure I-7) is paired with the fact that in the lower intertidal measurements in H12 still had ≥ 2 feet of cover. What is not evident from the elevation surveys is whether the EBS cover material is less than 2 feet of thickness in the areas of apparent erosion.

4 Conclusions

Collectively, the lines of evidence point to ongoing physical instability of the EBS cover material. Substantive erosion is shown in much of the EBS between post-construction (2008) and 2017. In some places, no cover is observed and the underlying cobble armor layer is exposed. The data suggest that erosion is ongoing and may not have stabilized. This conclusion is tempered however with considerable uncertainty relative to the comparability of the elevation survey data between the monitoring years, and by the fact that very limited direct-measurement data exists on EBS cover thickness.

While EBS maintenance actions appear to be warranted, the fact that the EBS cover remains an effective barrier to non-aqueous phase liquid seeping and contaminant advection, and is a functioning habitat for benthic invertebrates (see Section 4.4 of the 2017 Data Monitoring Report), it would be appropriate to further evaluate the relative physical stability of the EBS before making any construction-related maintenance decisions.

Specific recommendations for follow-up monitoring include:

- A systematic direct-measurement evaluation of the EBS cover thickness following the same methods used in this 2017 Data Monitoring Report. At a minimum, establish complete east-west transects on 5 foot contour intervals (e.g., +10 to +15, +5 to +10, 0 to +5, and -5 to 0 feet MLLW) and take measurements every 50 feet (for a total of 20 cross-transect measurements).
- Conduct additional comparisons between the methods used across the three different survey events to determine the actual degree of uncertainty associated with the elevation comparisons.
- Conduct an additional multibeam and lidar survey at a minimum one-year after the 2017 bathymetric survey. Compare the resulting data to the 2017 data to determine if further erosion has occurred.
- During the upcoming 2017-2018 winter rain storms, physically inspect the EBS to evaluate the stormwater outflow including measures of flow, direction of flow, and any evidence of erosion due to the outflow.

5 References

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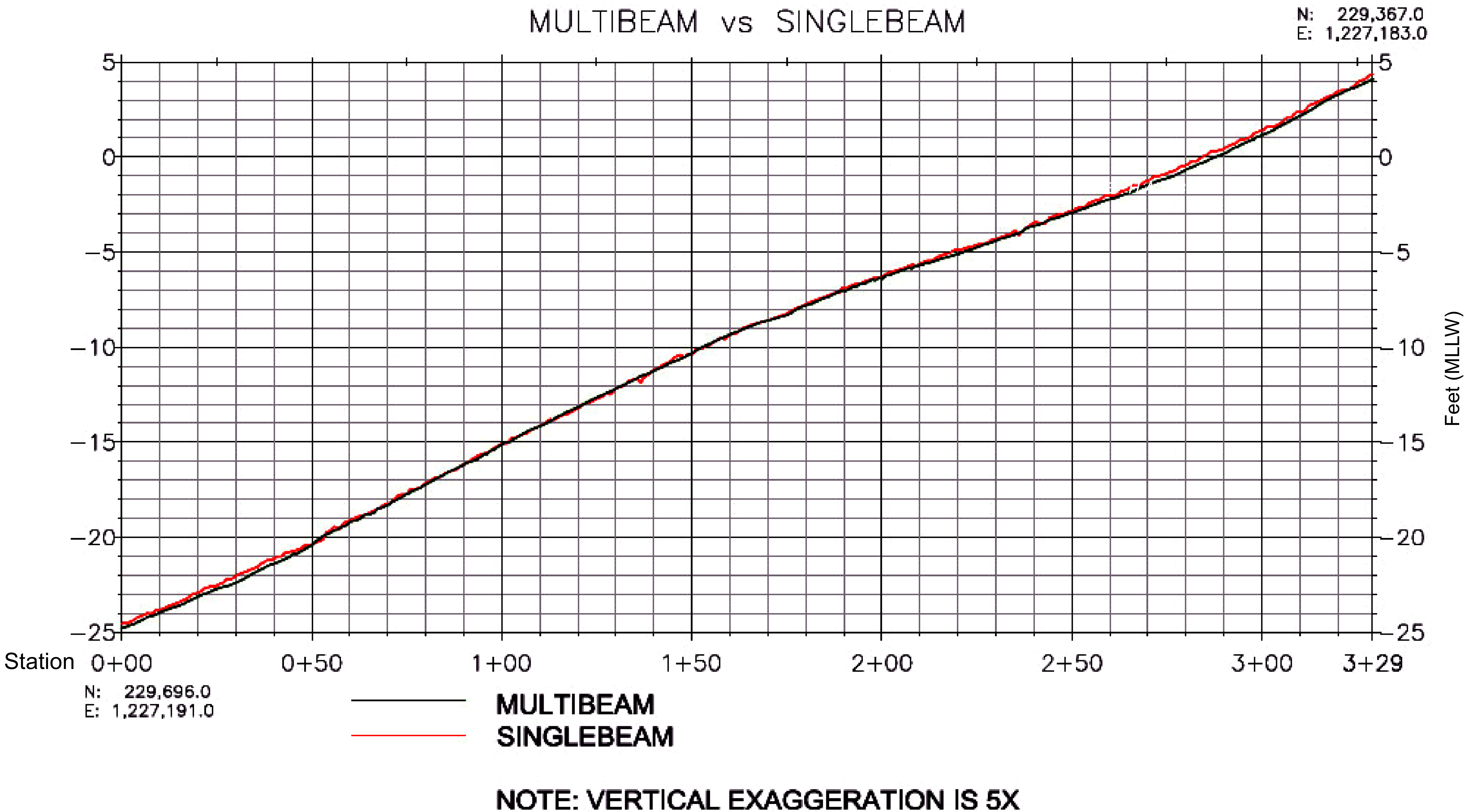
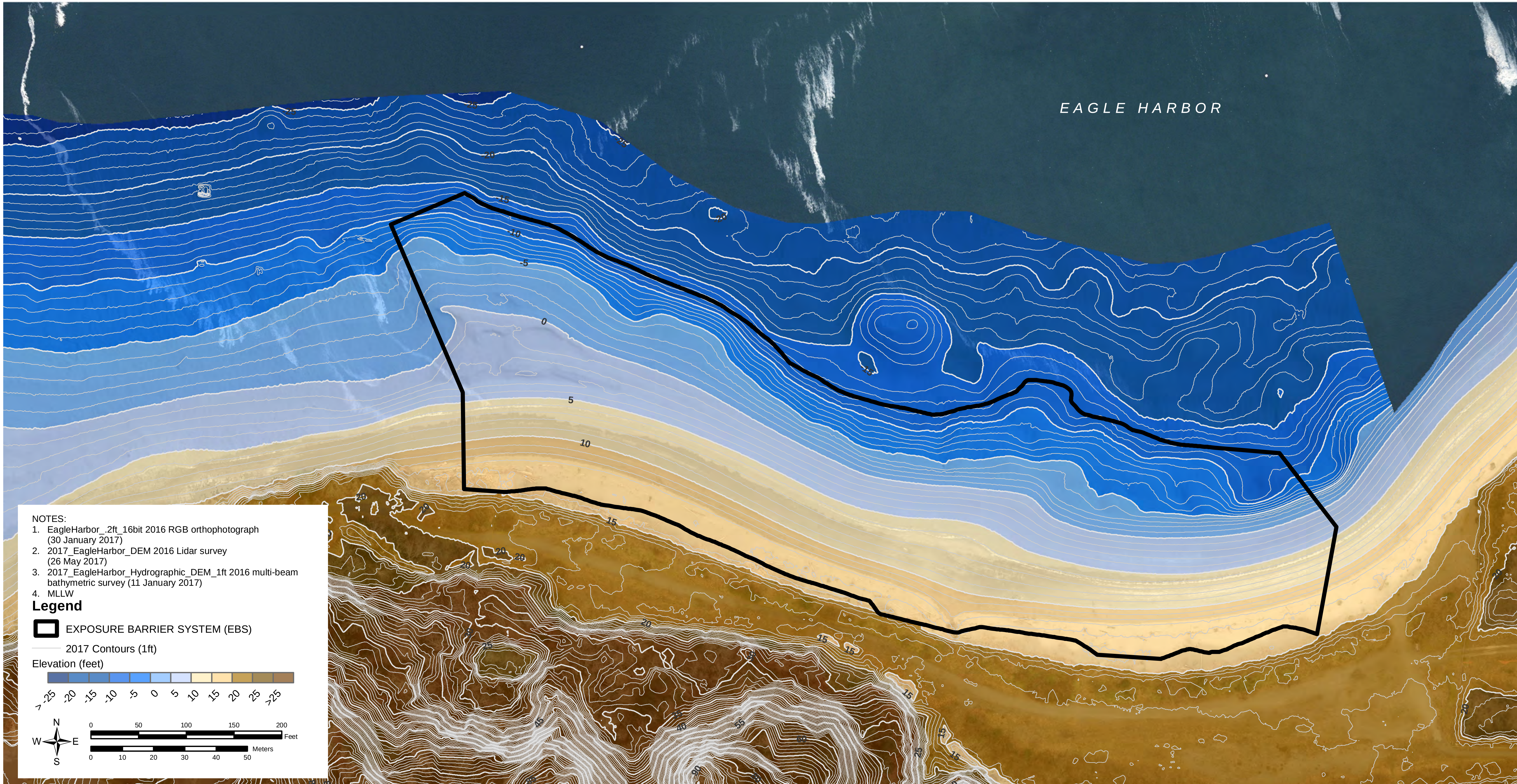


	Project Name	Figure Name	
SEE LLC Science & Engineering for the Environment / HDR	Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	Example Elevation Comparisons for Multi-beam and Single-beam Bathymetry	Figure I-1



Project Name	Figure Name	
Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	2017 Contours	Figure I-2

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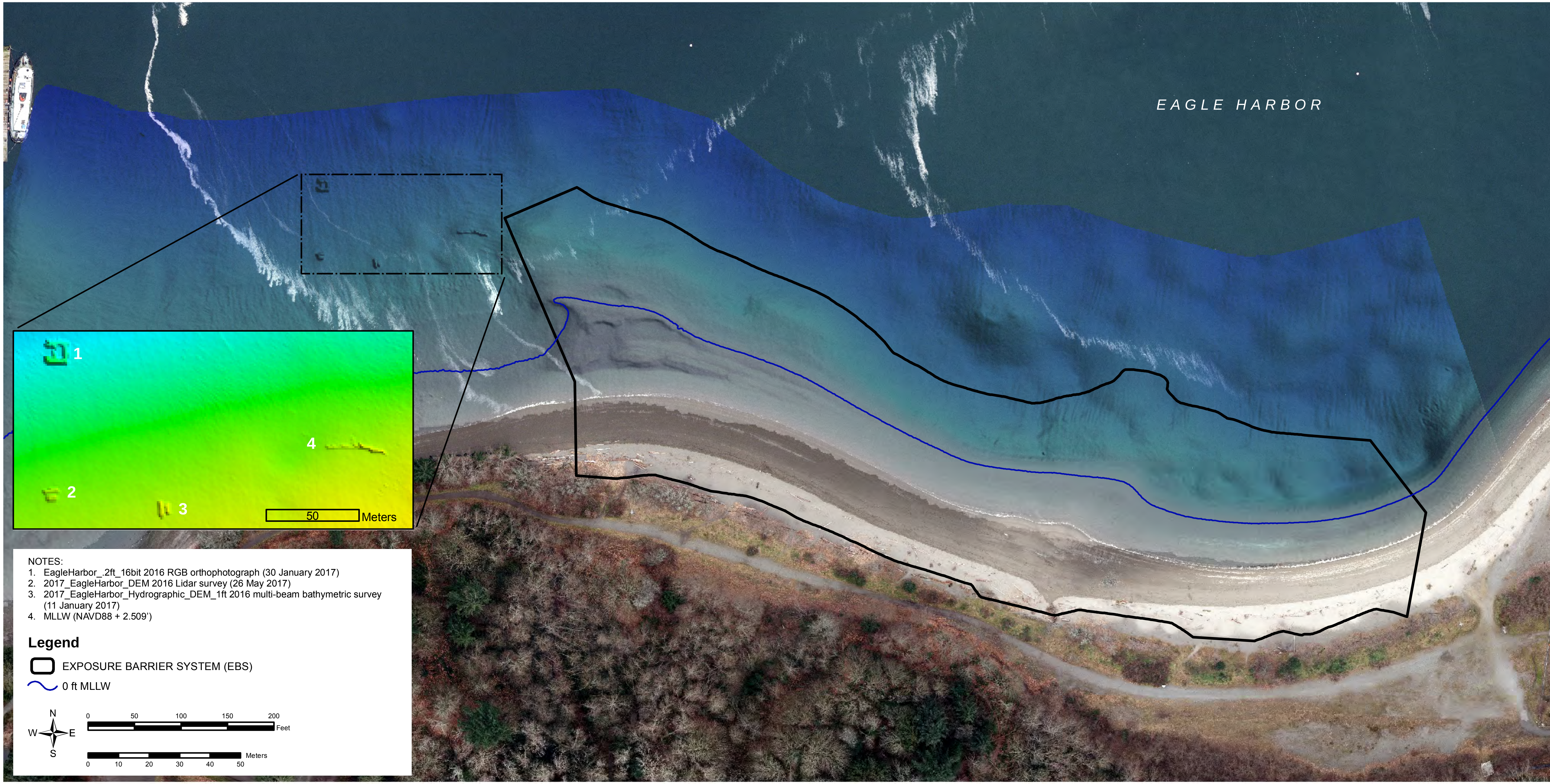

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SEE LLC Science & Engineering for the Environment / HDR	Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	2017 Combined Multibeam Sonar Survey With Lidar and Aerial Imagery	Figure I-3

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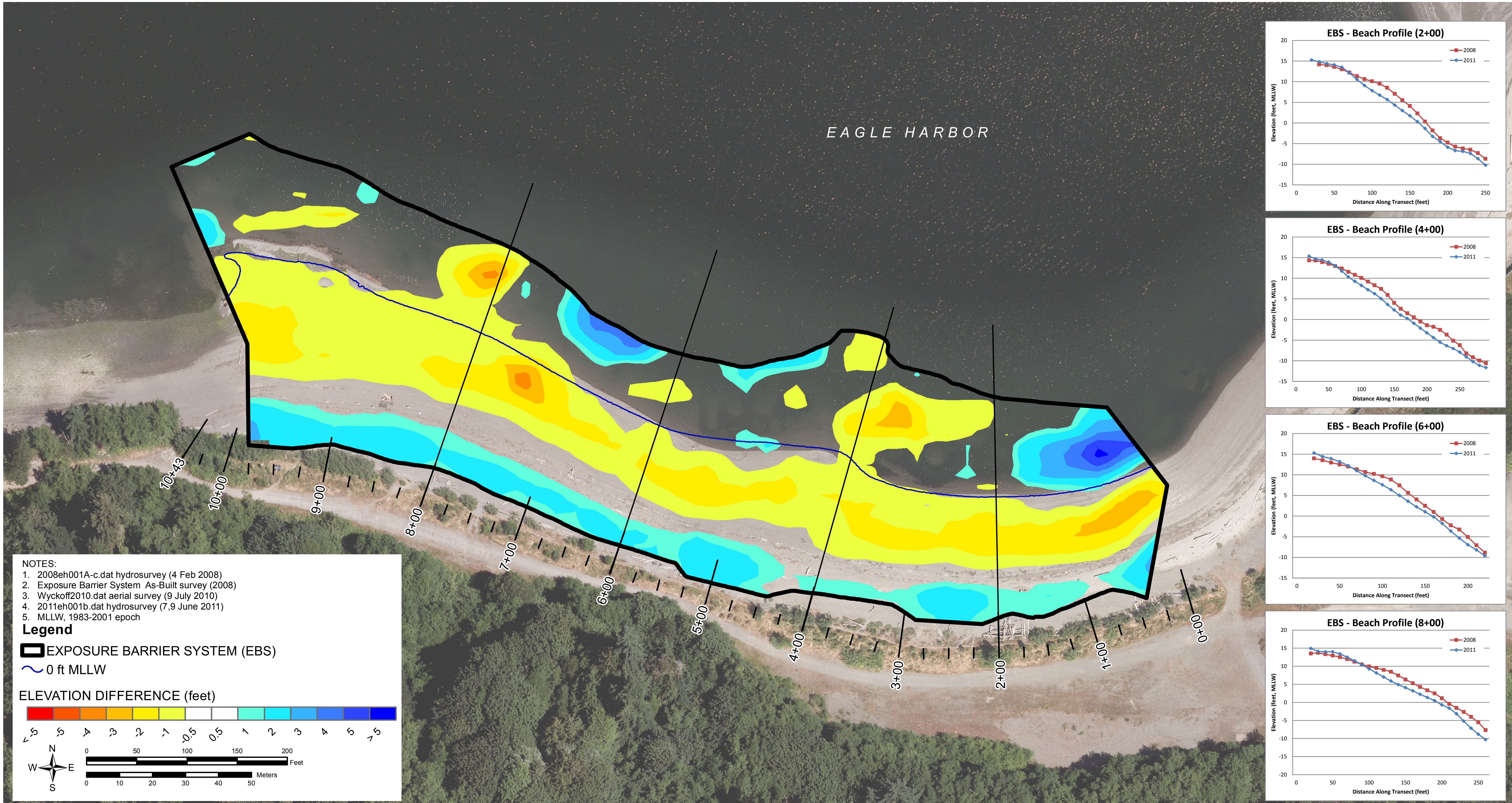

Project Name	Figure Name	
Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	Elevation Difference 2008 to 2011	Figure I-4

SEE LLC Science & Engineering for the Environment
HDR

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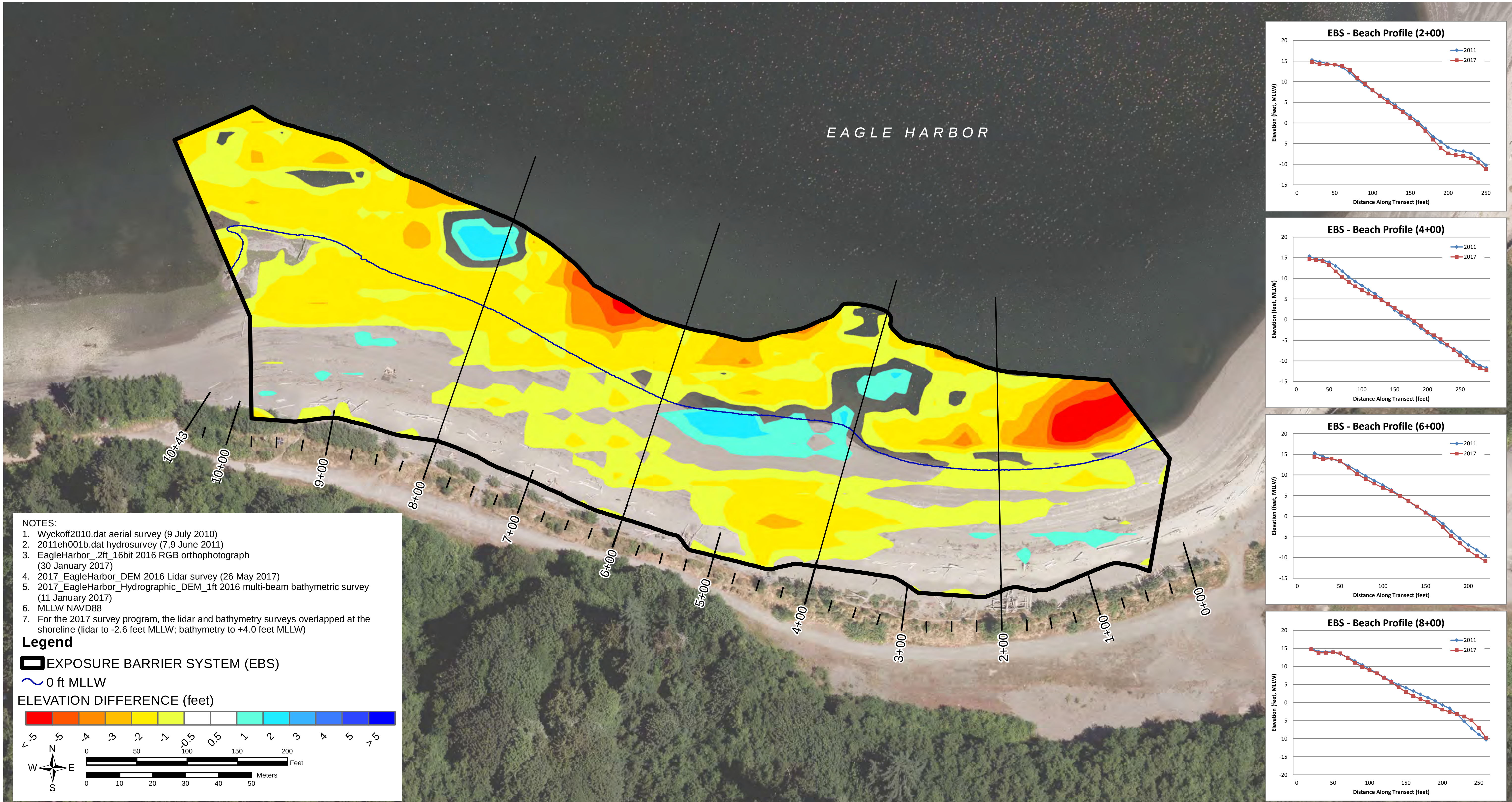
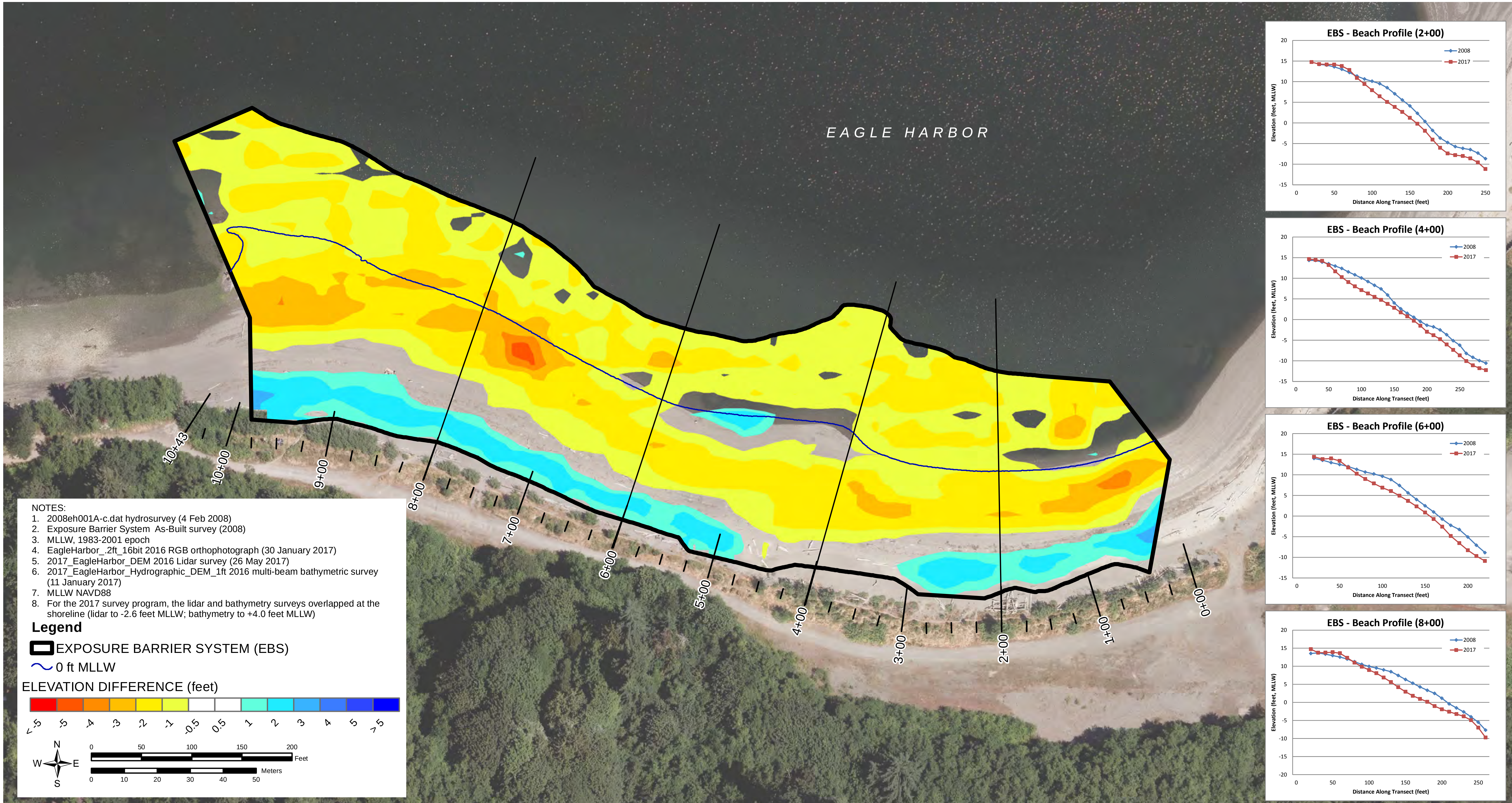


Project Name	Figure Name	
Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	Elevation Difference 2011 to 2017	Figure I-5

SEE LLC — Science & Engineering for the Environment | HDR



Project Name	Figure Name	
Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	Elevation Difference 2008 to 2017	Figure I-6

\\bel-srv03\GISDATA\Projects\Washington\USACE_008898\Eagle_Harbor_10049950\7.2_WP\Map_Docs\SurveyMemo\I6_2008_2017.mxd

Project Name	Figure Name	
Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	2011 vs 2017 EBS Cover Measures	Figure I-7

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HDR

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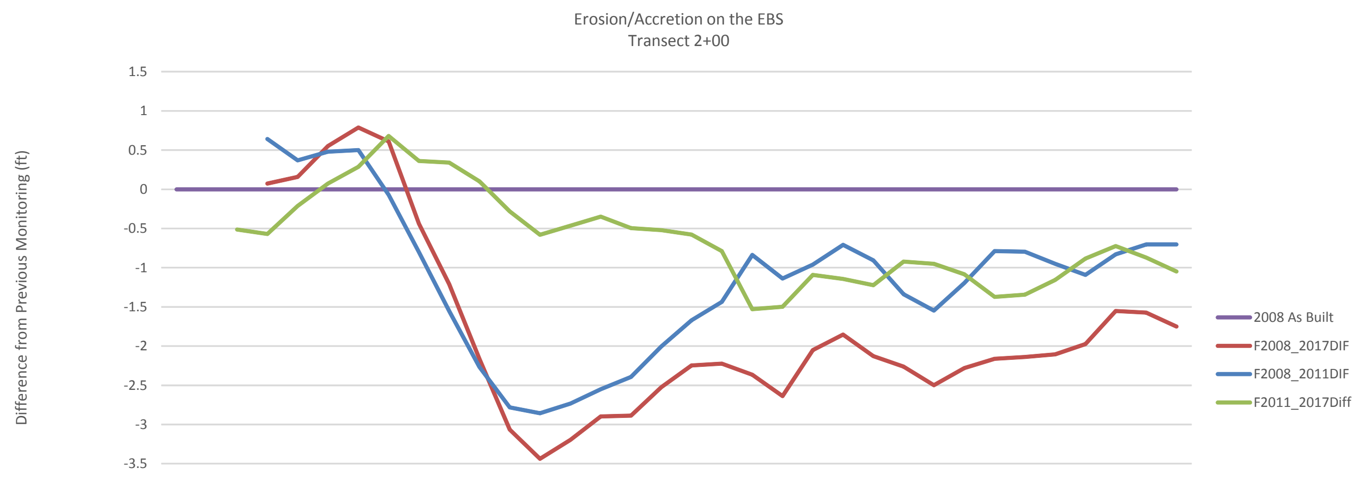
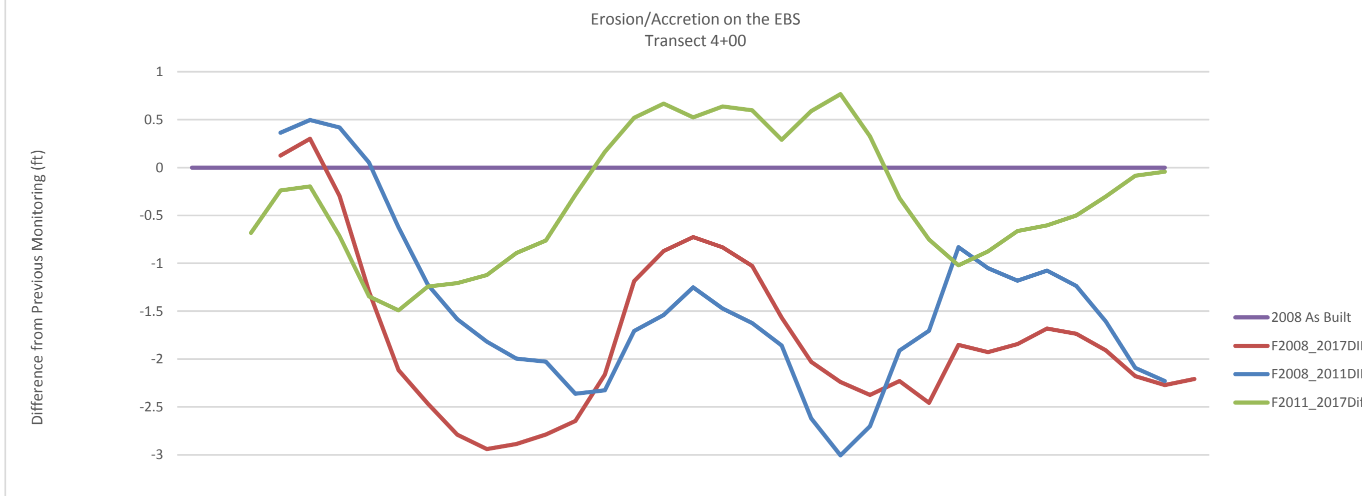


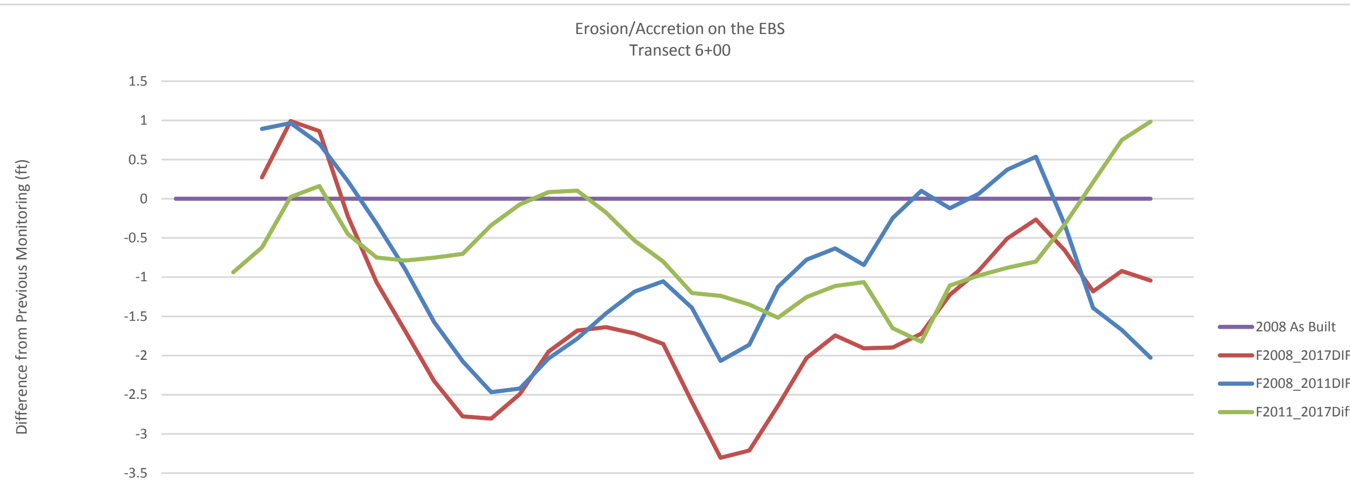
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330
2008 As Built	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F2008_2017DIF				0.07	0.16	0.55	0.79	0.61	-0.4	-1.2	-2.1	-3.0	-3.4	-3.2	-2.9	-2.8	-2.5	-2.2	-2.2	-2.3	-2.6	-2.0	-1.8	-2.1	-2.2	-2.5	-2.2	-2.1	-2.1	-2.1	-1.9	-1.5	-1.5	-1.7
F2008_2011DIF				0.64	0.37	0.48	0.50	-0.0	-0.8	-1.5	-2.2	-2.7	-2.8	-2.7	-2.5	-2.3	-2.0	-1.6	-1.4	-0.8	-1.1	-0.9	-0.7	-0.9	-1.3	-1.5	-1.2	-0.7	-0.8	-0.9	-1.0	-0.8	-0.7	-0.7
F2011_2017Diff			-0.5	-0.5	-0.2	0.07	0.29	0.68	0.36	0.34	0.10	-0.2	-0.5	-0.4	-0.3	-0.5	-0.5	-0.5	-0.7	-1.5	-1.5	-1.0	-1.1	-1.2	-0.9	-0.9	-1.0	-1.3	-1.3	-1.1	-0.8	-0.7	-0.8	-1.0

Transect Point Distance from On-Shore (ft)



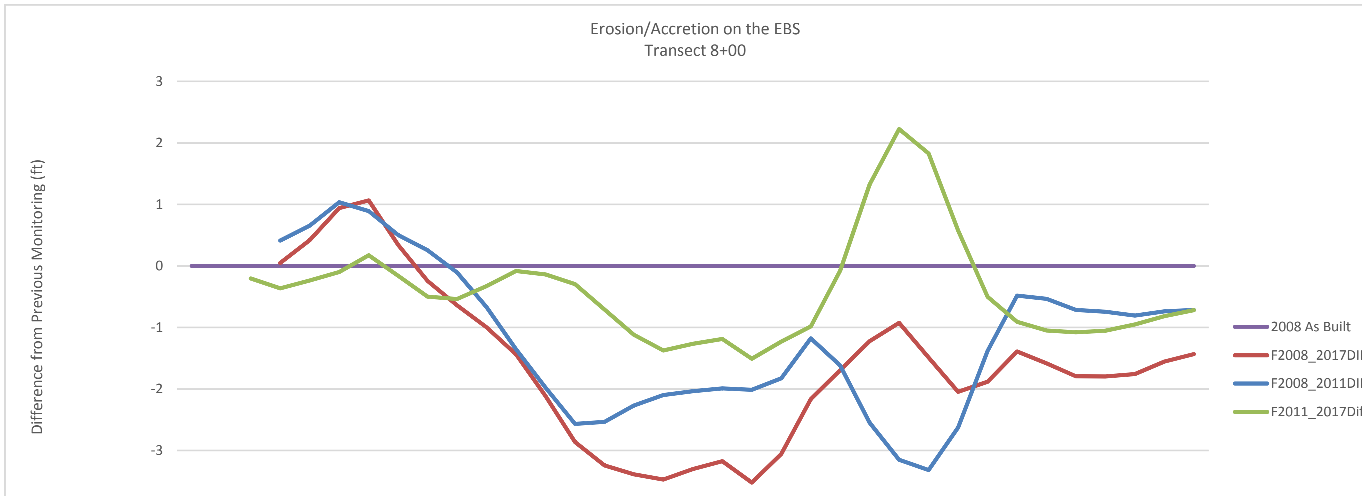
	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	
2008 As Built	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
F2008_2017DIF				0.13	0.30	-0.3	-1.2	-2.1	-2.4	-2.7	-2.9	-2.8	-2.7	-2.6	-2.1	-1.1	-0.8	-0.7	-0.8	-1.0	-1.5	-2.0	-2.2	-2.3	-2.2	-2.4	-1.8	-1.9	-1.8	-1.6	-1.7	-1.9	-2.1	-2.2	-2.2
F2008_2011DIF				0.36	0.50	0.42	0.05	-0.6	-1.2	-1.5	-1.8	-1.9	-2.0	-2.3	-2.3	-1.7	-1.5	-1.2	-1.4	-1.6	-1.8	-2.6	-3.0	-2.7	-1.9	-1.7	-0.8	-1.0	-1.1	-1.0	-1.2	-1.6	-2.0	-2.2	
F2011_2017Diff			-0.6	-0.2	-0.2	-0.7	-1.3	-1.4	-1.2	-1.2	-1.1	-0.8	-0.7	-0.2	0.16	0.52	0.67	0.52	0.64	0.60	0.29	0.59	0.77	0.33	-0.3	-0.7	-1.0	-0.8	-0.6	-0.6	-0.5	-0.3	-0.0	-0.0	

Transect Point Distance from On-Shore (ft)



	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	
2008 As Built	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F2008_2017DIF				0.27	0.99	0.87	-0.2	-1.0	-1.6	-2.3	-2.7	-2.8	-2.4	-1.9	-1.6	-1.6	-1.7	-1.8	-2.5	-3.3	-3.2	-2.6	-2.0	-1.7	-1.9	-1.9	-1.7	-1.2	-0.9	-0.5	-0.2	-0.6	-1.1	-0.9	-1.0
F2008_2011DIF				0.89	0.97	0.70	0.23	-0.3	-0.9	-1.5	-2.0	-2.4	-2.4	-2.0	-1.7	-1.4	-1.1	-1.0	-1.3	-2.0	-1.8	-1.1	-0.7	-0.6	-0.8	-0.2	0.10	-0.1	0.06	0.37	0.54	-0.3	-1.3	-1.6	-2.0
F2011_2017Diff			-0.9	-0.6	0.03	0.16	-0.4	-0.7	-0.7	-0.7	-0.7	-0.3	-0.0	0.09	0.10	-0.1	-0.5	-0.8	-1.2	-1.2	-1.3	-1.5	-1.2	-1.1	-1.0	-1.6	-1.8	-1.1	-0.9	-0.8	-0.8	-0.3	0.21	0.75	0.98

Transect Point Distance from On-Shore (ft)



	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	
2008 As Built	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F2008_2017DIF				0.05	0.42	0.94	1.07	0.34	-0.2	-0.6	-1.0	-1.4	-2.1	-2.8	-3.2	-3.3	-3.4	-3.3	-3.1	-3.5	-3.0	-2.1	-1.7	-1.2	-0.9	-1.4	-2.0	-1.8	-1.3	-1.5	-1.8	-1.8	-1.7	-1.5	-1.4
F2008_2011DIF				0.41	0.66	1.04	0.89	0.50	0.26	-0.1	-0.6	-1.3	-1.9	-2.5	-2.5	-2.2	-2.1	-2.0	-1.9	-2.0	-1.8	-1.1	-1.6	-2.5	-3.1	-3.3	-2.6	-1.3	-0.4	-0.5	-0.7	-0.7	-0.8	-0.7	-0.7
F2011_2017Diff			-0.2	-0.3	-0.2	-0.1	0.17	-0.1	-0.5	-0.5	-0.3	-0.0	-0.1	-0.2	-0.7	-1.1	-1.3	-1.2	-1.1	-1.5	-1.2	-0.9	-0.0	1.32	2.23	1.83	0.58	-0.5	-0.9	-1.0	-1.0	-1.0	-0.9	-0.8	-0.7

Transect Point Distance from On-Shore (ft)

	Project Name	Figure Name	
SEE LLC Science & Engineering for the Environment; HDR	Survey Program Technical Memorandum Wyckoff/Eagle Harbor Superfund Site	Comparison of Erosion/Accretion by Year and Beach Profile Transect	Figure I-8

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Appendix I-1a. TerraSond Eagle Harbor Project Report

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Project Summary

TerraSond, Limited performed multibeam and single beam hydrographic surveys at Eagle Harbor offshore of Bremerton Island, WA. The field survey took place January 11, 2017. The survey area is shown below. Coverage extends to as near to shore as was safely navigable.

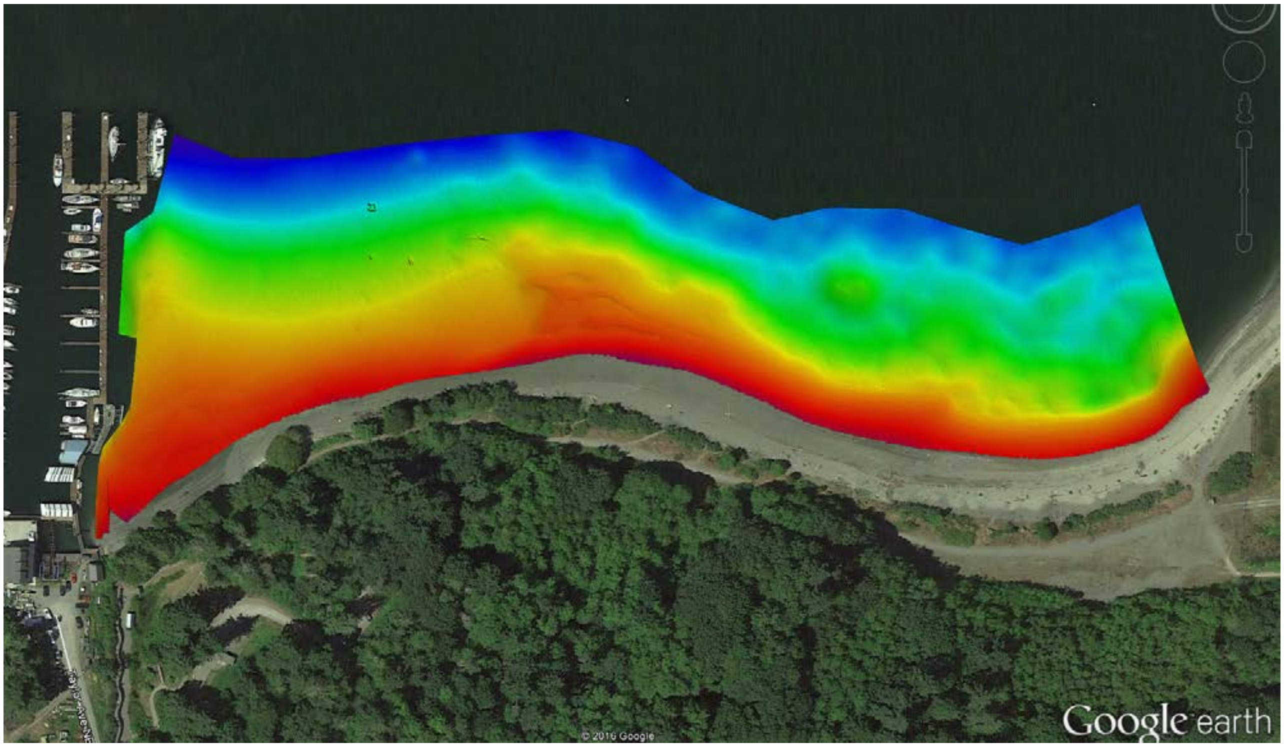

Figure 1 – Survey Area

Survey Control

Datums

Horizontal Datum

The survey data was collected using Washington State Plane North Zone NAD83 (2011) in US Survey Feet from the TerraSond Office base station. The final deliverables were completed in Washington State Plane North Zone NAD83 (91). A shift was computed using 3 monuments in the area to determine the horizontal difference at the project site between NAD83 (2011) and NAD83 (91). This difference was then applied to each point set. The average used in the calculations was 0.374 USFT in X and 0.345 USFT in Y.

Vertical Datum

Survey Data was collected on the ellipsoid from the TerraSond Office base station, the base station equipment is a Trimble Global Positioning System (GPS) model NetRS. The NAVD88 (North American Vertical Datum of 1988) Height was computed for both the single beam and the multibeam data by applying Geoid 12A during data processing. The Mean Lower Low Water (MLLW) values were computed using the difference from the Washington State Department of Transportation (Wash DOT) monument IS1825 and Monument ID5139.

Wash DOT IS1825
NAVD88 Elevation 18.261 US FT
MLLW Elevation 20.77 US FT
Difference applied from NAVD88 to MLLW 2.509 US FT

Table 1 – Control Checks

Station		Northing	Easting	Elevation (NAVD88)
IS1825	REC	231634.58	1226908.01	18.26
IS1825	Check	231634.61	1226908.15	18.34
IS1825	Check	231634.60	1226908.19	18.31

Figure 2 IS1825 Looking southeast and IS1825 monument

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Survey Equipment

Table 2 - Survey Equipment

Component	Model	Description
Multibeam Echosounder	R2 Sonic 2024	400kHz multibeam, 0.5 degree beamwidth.
Single beam Echosounder	Odom EchoTrac	Dual Frequency, 3° single beam puck
Inertial Navigation System/RTK GPS	Coda F185	Position, heave, pitch, roll and heading sensor.
Real Time Kinematic (RTK) Base Station	Trimble R8	Dual frequency, low-latency base GPS receivers.
Sound Velocity Profiler	AML Minos X	Internal recording, 500dBar instrument for measuring sound velocity profiles.
Acquisition Software	QINSy 8.1	Hydrographic data acquisition and navigation software.
Processing Software	Caris HIPS 9.1	Hydrographic data cleaning and processing software.

Vessel

The vessel used in the survey was the *R/V Carta*, TerraSond's 27-foot, custom built, shallow draft, aluminum survey platform. The vessel is equipped with an over-the-side multibeam pole mount. The mount has a rotary actuator that swings the pole outboard to deploy the sonar. The pole is bolted into place during the survey. The single beam was mounted in the moon pool at mid-ship and slightly to the port side.

The inertial navigation system used for the survey is a Coda F185. The F185 consists of a motion reference unit (MRU) coupled with two GPS receivers. The MRU is rigidly mounted near the vessel center of gravity, the antennas are mounted port and starboard on the forward cabin roof. The F185 supplies Real Time Kinematic (RTK) position, heading, heave, pitch and roll corrections to the soundings.

Figure 3 - RV Carta

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Data Acquisition Procedures

Data was collected on the 11th of January, the survey crew started data collection around 12:00 noon local time and ended around 4:00pm. The data was collected in UTC time as seen in the field notes. Single beam lines were run first and then the multibeam lines were acquired.

Hypack 2016 was utilized for acquisition of the single beam data. The software generates a trackline map and displays it over the planned lines to aid the acquisition personnel in determining real time across track error. The tracklines from the June 2011 survey were digitized into AutoCAD and imported into Hypack. These line were driven as closely as possible. A total of 20 single beam survey lines were run.

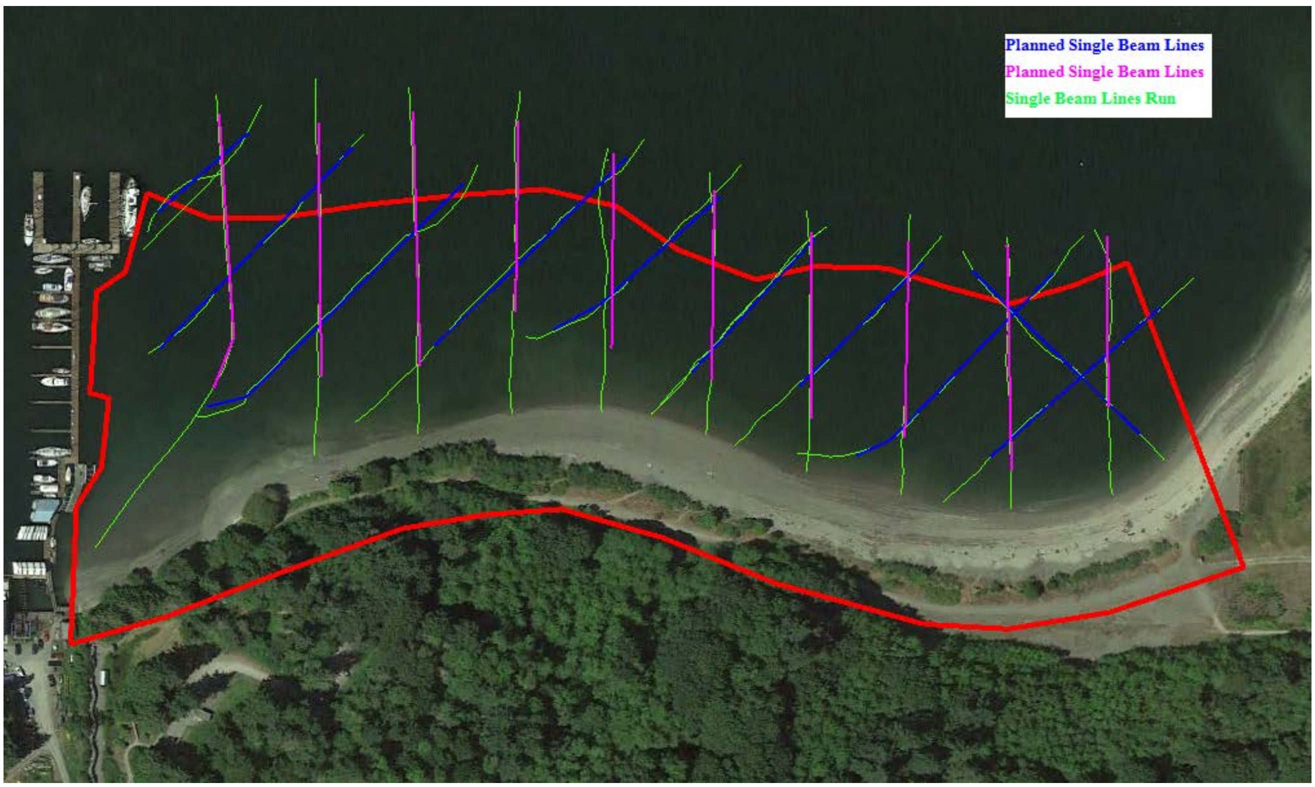

Figure 3 Planned single beam lines in blue and magenta. Single beam lines actually acquired are in green.

QPS QINSy data acquisition software was used for data collection. The software generates a real-time, corrected coverage map of the survey data and quality assurance tools to verify the quality of the data. Line spacing was variable depending on the depths. Generally, the multibeam survey lines were run parallel to the beach and they overlapped between adjacent lines at around 50% of the previous line. Survey speeds were typically 3-5 knots.

A total of three sound velocity casts were taken over the duration of the survey at approximately 2 hour intervals throughout the survey. Sound velocity profiles were used to correct soundings for time-of-flight and beam refraction in post processing.

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Processing Procedure

Multibeam Processing

All multibeam data was processed using Caris HIPS version 9.1. HIPS provides data processing tools that allow you to take all of the raw sensor data recorded during data acquisition and create a final sounding set. The general HIPS workflow is composed of the following steps:

1. Data Conversion. Raw data is converted from the native QINSy format to a HIPS format.
2. Sensor editing. Sensor data such as heave, pitch roll and navigation is reviewed. The data can be edited for spikes, smoothed, interpolated or rejected if necessary.
3. Sound velocity Processing. Sound velocity processing converts the soundings from raw beam angle and time of flight measurements to soundings based on the sound velocity profile of the water column and vessel attitude measurements. Vessel offset parameters computed from patch test results and vessel survey offsets are applied during this step.
4. Swath editing. Soundings from individual lines are cleaned in the swath editor. The swath editor allows the hydrographer to examine and reject erroneous data and filter lines based on swath limits.
5. Merging. Water level and other vertical corrections are applied to the soundings. The soundings are converted from time, beam and ping format referenced to the vessel location, to a fully geo-reregistered sounding.
6. Subset Editing. Subset editing is the final step in the data cleaning process. The subset editor allows the hydrographer to view data from multiple survey lines in a region in a single 2D and 3D spatial editor.
7. Surface Processing. After the data has been cleaned and finalized, HIPS creates a gridded surface from the data called a base surface. The horizontal resolution of the surface is user specified and depends on the resolution of the acquired data and the accuracy requirements.

Single Beam Processing

All single beam data was processed using Hypack 2016 Single beam editor. The echogram was loaded into Hypack and the sounding values compared to the echogram. Soundings were interpolated based on the echogram comparison. The final points were exported into ASCII as a 1 ft sort.

Results

The multibeam and single beam are within 0.1-0.2 ft in general to one another. The multibeam tends to be lower than the single beam. This data was analyzed by using AutoCAD Civil 3D 2013. The multibeam and single beam xyz data were brought into AuotCAD. Surfaces were created for each data set. 5 profile lines, spaced across the survey from east to west, were drawn in AutoCAD and the surfaces compared along these lines. A representative profile between the two surveys is shown below.

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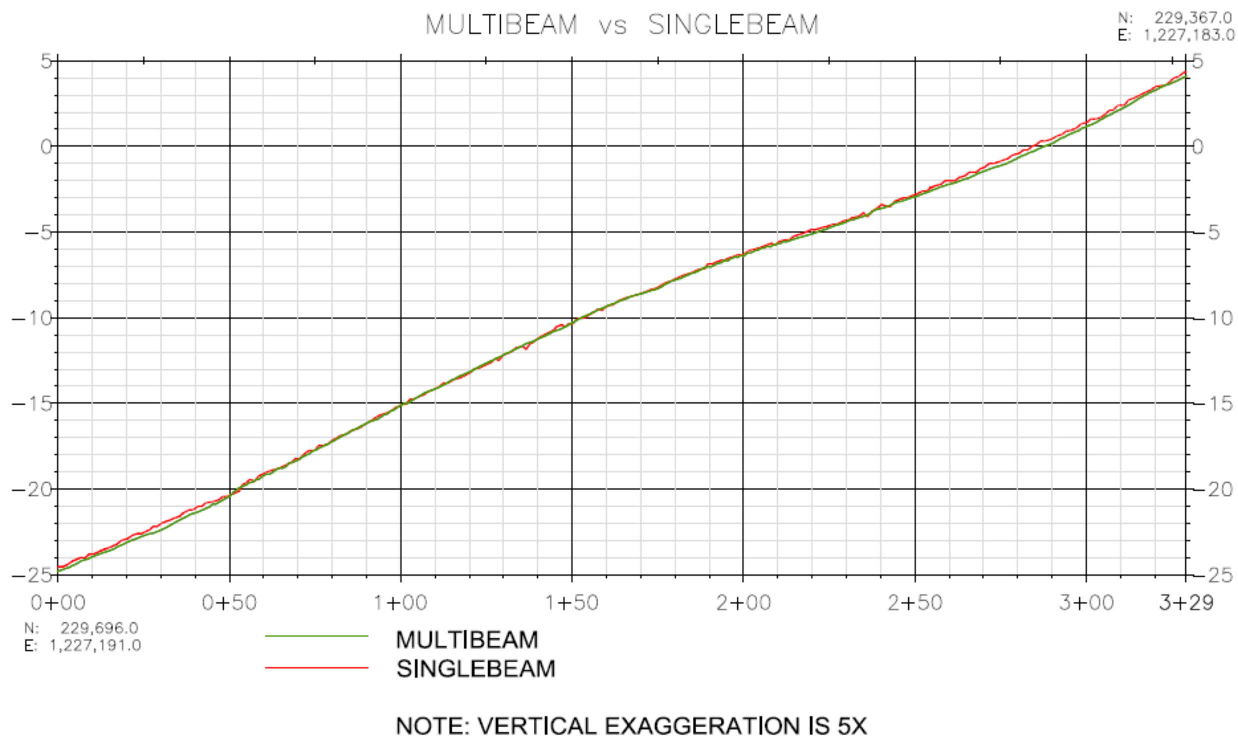

Figure 4 Multibeam and single beam comparison

The crossline comparison for the single beam data against itself compared well within the expected parameters for a single beam survey. Each intersection was visually compared in the software program Hypack 2016. A typical cross section is seen below.

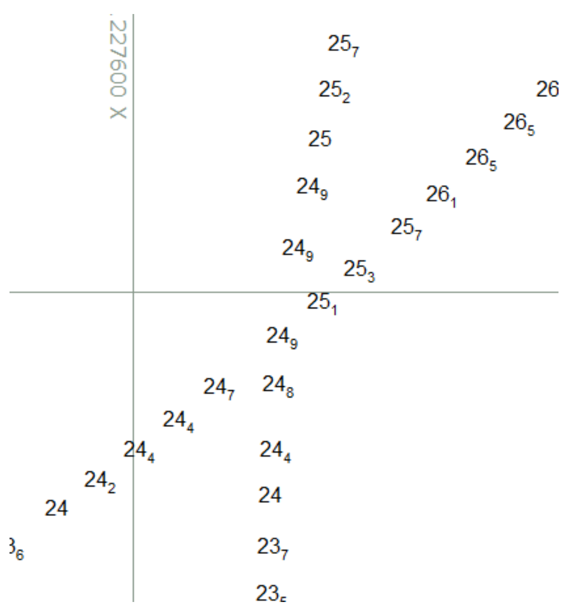

Figure 5 Single beam crossline intersection. Soundings in feet.

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Quality Control Checks

Prior to surveying, during data collection and in post processing, a series of quality assurance checks were conducted to verify the sounding accuracies. The checks that were conducted included:

1. Control Check (Described in Survey Control Section)
2. Bar Check
3. Lead Line Check
4. Patch Test

Bar Check

A bar check was conducted to verify sonar sounding accuracy and the vertical offsets applied in post processing. A bar was lowered below the sonar and multibeam raw files were recorded at each depth. The raw files were processed using the standard processing flow in Caris HIPS. This accounts for all vertical offsets for the positioning and multibeam locations, sonar draft and sound velocity.

Table 4 – Multibeam Bar Check

Bar Depth (ft)	MBES Depth (ft)	Difference (ft)
5.0	4.88	0.12
10	9.94	0.06
15	14.84	0.16
20	19.83	0.17

A single beam bar check was completed at the beginning of the survey and at the end of the survey. The bar started at 10 ft depth and sound velocity set to 4800. The bar was reading deeper than it should have been so the draft was adjusted to 1.2. The bar was then lowered to 30 ft and the nadir depth was reviewed to see if an adjustment was needed to the sound velocity or the draft. The process was checked at the end of the survey with no changes made.

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Table 5 – Single beam Bar Check

Bar Depth (ft)	Nadir Depth (ft)	Sound Velocity	Draft	Index
10	10.2	4800	1.3	0
10	10.0	4800	1.2	0
30	30.0	4800	1.2	0

Lead Line Check

A lead line was utilized to verify that the acquisition software was reading the appropriate depth, it was not used in any calibration procedure. For this survey it is used as a gross error quality check. Lead lines are not overly accurate for two main reasons; the first is that when the lead line is lowered over the side of the vessel it is not on to a flat seafloor so the reading you take off the lead line is different than the sounder reading, the second issue arises when the technician takes the reading off the lead line, they are trying to read the waterline on the tape measure as the vessel moves up and down this creates an error in the measurement as well.

System	Lead Line value	Sonar value	Delta
Single Beam	41.8 ft	41.2 ft	0.6 ft
Multibeam (Port)	38.0 ft	36.3 ft	1.7 ft
Multibeam (Starboard)	35.5 ft	34.5 ft	1.0 ft

Patch Test

A patch test is a set of systematic lines that are run to determine the alignment errors between the motion reference unit and the multibeam. Roll, pitch, yaw and latency patch lines were run and biases determined using the Caris HIPS calibration utility.

Table 6 – Patch Results

Pitch (deg)	Roll (deg)	Yaw (deg)
-3.800	-1.640	-0.600

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Deliverables

The deliverables provided for this project include: Two sets of data, one overall and one of the inset.

- ASCII X,Y,Z point files of bathymetric points. Gridded at 1ft x 1ft
  - Multibeam files are noted with a MBES,
  - Single beam as a SBES.
- Sun-illuminated imagery of multibeam data in GEOTIF format (TIF/TFW)
  - Wyckoff_WASPZN_MLLW_1ft_SetRange.tif has a set color range of 0 to +4 mllw as green and +4 to the shoalest sounding as red.
- Project report summarizing data collection and processing procedures.

TERRASOND
TERRESTRIAL AND SEA FLOOR MAPPING

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SEATTLE, WA 98107
(206) 420-8304
www.terrasond.com

Project Information:

Project Name:	2017-003 MCA Wyckoff	Date:	1/11/17
Project Number:	2017-003	JD:	JD011
Location:	Eagle Harbor, WA		

Personel:

Position	Name	Company
Party Chief:		
Lead Hydrographer:	Kathleen Mildon	TerraSond
Survey Tech:	Andrew Smith	TerraSond
Survey Tech:	Tyler Yost	TerraSond
Client:		
Client:		

Equipment

	Model	Serial #	Version
Multibeam	R2Sonic 2024		
Inertial Navigation	F185		
Positioning	F185		
Heading	F185		
HPR	F185		
SVP Probe	AML Micro SV Minos X		
Acquisition Software	Qinsy QPS/MBES	Hypack 2016/SB	

Coordinate System:

Horizontal Datum:	Washington State plane Zone N NAD83		
Coordinate System:		Units:	
Vertical Datum:	NAVD88	Units:	Ft

Positioning:

		Station:
Horizontal:	Coast Guard DGPS	
	Local Base Station	
Vertical:	RTK	TerraSond Shop
	Tide Gauge	

Notes:

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Project Information:

Project Name: 2017-003 MCA Wyckoff   Date: 1/11/2017
Project Number: 2017-003   JD: 011
Location: Eagle Harbor   Crew: KM, AS, TY

Conditions

Weather: 35° F
Wind: 25 KTS   Seas: >2 Ft
Traffic:

Draft Measurements WATERLine

Begin Shift	Reference	Ref -Offset	(--)	WL	MB - Offset	Draft
Port	P2			2.84	-2.06	.78
Starboard	~~R2~~ S2			2.81	-2.06	.75
End Shift						
Port						
Starboard						

Position Check:

Reference Station:

	Record: R8	Measured: R8	Delta
Northing:	N: 231293.741	N: 231293.54	N: 0.20
Easting:	E: 1225098.745	E: 1225028.74	E: 0.01
Elevation:	El: 13.110	El: (HI 7.23) 6.02 (13.25)	El: 0.14

Sound Velocity Casts:

Date	Time	Latitude	Longitude	SV Depth
1/11/17 ~~Digibar~~ AML	19:43	47°37.1723N	122°31.0468	
1/11/17 AML	21:23	47°37.0318N	122°30.4774	
1/11/17 AML	23:57	47°37.0691N	122°30.3635	

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Project Information:

Project Name: MCA wyckoff
Date: 1/11/17
Project Number: 2017-003
JD: 011
Location: Eagle harbor
Crew: KM/AS/TY

Conditions

Weather: 40 ~~K~~ °F
Wind: no wind
Seas: Flat
Traffic: no traffic

Offsets

Antenna ARP to Bottom of Transducer: ______
Antenna ARP to Waterline: ______
Waterline to Bottom of Transducer: ______

Single Beam Bar check

Bar Check Begin

Bar Depth	ND	~~Nadir Depth~~ Sound velo.	~~Surface SV~~ index Draft	Draft	Delta
10 ft	10.2	4800 index 0	Draft 1.3	index Calibration 1.2	Draft channel
30 ft	30.0	4800 ~~index~~	Draft ~~1.3~~ 1.2		

Bar Check End

Bar Depth	Nadir Depth	Surface SV	Draft	Delta
10 ft	10 ft	4800	Draft 1.2	
30 ft	30 ft	4800	Draft 1.2	

Notes:

TERRASOND
TERRESTRIAL AND SEA FLOOR MAPPING

801 NW 42ND STREET, SUITE 215
SEATTLE, WA 98107
(206) 420-8304
www.terrasond.com

Project Information:

Project Name: 2017-003 McA Wyckoff
Date: 1/11/17
Project Number: 2017-003
JD: 011
Location: Eagle harbor
Crew: KM/AS/TY

Conditions:

Weather: 35°F
Wind: 20 Knts
Seas: Flat
Traffic: None

SBES

Survey Lines:

Line Name	Start	Stop	Speed	HDG	Comment
011-003-2007	2007	2009	4.00	185	
011-004-2009	2009	~~2009~~ 2010	7.00	42	latency line
011-005-2011	2011	2012	7.25	226	latency line
011-003-2014	2014	2015	4.00	55	
011-005-2016	2016	2018	5.00	234	
011-006-2021	2021	2023	7	230	
011-007-2025	2025	2027	7.5	230	
011-008-2029	2029	2030	7.0	230	
011-009-2033	2033	2035	7.0	230	Good patch area.
011-010-2036	2036	2038	7.2	220	
011-011-2040	2040	2041	7.2	230	
011-012-2043	2043	2045	7.2	130	Bad Sync Error Flash
011-001-2047	2047	2049	6.5	183	
011-002-2050	2050	2052	6.5	180	
011-003-2053	2053	2054	7.0	180	
011-004-2056	2056	2057	7.0	180	
011-006-2059	2059	21:00	7.0	180	
011-007-2102	2102	21:03	7.0	180	Bouy on line
011-009-2105	2105	21:06	7.0	177	
011-010-2108	2108	21:10	7.0	174	possible patch at end of line
011-011-2112	2112	2113	7.0	181	
011-012-2115	2115	2119	7.5	175	

Notes:

Lead Line: 47 37.1723 N 122 31.0418 W eChart Depth 41.2 ft
LL Depth WL 41.8 ft

Line Notes

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(206) 420-8304
www.terrasond.com

Project Information:

Project Name: 2017-003 MCA Wyckoff
Date: 1/11/17
Project Number: 2017-003
JD: 011
Location: Eagle harbor
Crew: KM/AS/TY

Conditions

Weather: 45° F
Wind: 5 Knts
Seas: <1 ft
Traffic: None

Offsets

Antenna ARP to Bottom of Transducer: ______
Antenna ARP to Waterline: ______
Waterline to Bottom of Transducer: ______

MultiBeam Bar check

Bar Check Begin

Bar Depth	Nadir Depth	Surface SV	Draft	Delta
5 ft.				
10 ft.				
15 ft.				
20 ft.				

Bar Check End

Bar Depth	Nadir Depth	Surface SV	Draft	Delta

Notes:

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(206) 420-8304
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Project Information:

Project Name: 2017-003 MCA Wyckoff
Date: 1/11/17
Project Number: 2017-003
JD: 011
Location: Eagle Harbor
Crew: KM/AS/TY

Conditions:

Weather: 45°F
Wind: 5 KNts
Seas: <1ft
Traffic: none

Survey Lines:

Line Name	Start	Stop	Speed	HDG	Comment
0002-MCA					Bar check
0003-MCA	2224	2229			
0004-MCA	2231	2236			
0005-MCA	2237	2245			Dock face
0006-MCA	2245	2247			
0007-MCA	2248	2249			
0008-MCA	2250	22			
09	—	—			
10-MCA	2259	2306			
0011-MCA	2306	2318			
0012-MCA	2319	2320			
0013-Mca	2321	2323			
0014-Mca	2324	2324			
0015-Mca	2324	2325			
0016-Mca	2325	2325			
0017-MCA	2326	2321			
0018-Mca	2322	2329			
0019-~~Mca~~ Patch	2337	2338			patch
0020-~~Mca~~ Patch	2340	2341			patch
0021-PATCH	2342	2343			PATCH
0022-PATCH	2347	2348			PATCH
0023-PATCH	2350	2350			PATCH
0024 PATCH	2351	2352			PATCH

Notes:

Lead Line 38.0 to WL > port chk
depth on MBES 36.3
Leadline 35.5
MBES 34.5

0025 PATCH 2352 2353
0026 PATCH 2353 2354
0027 PATCH Y 2354 2354
0028 PATCH Y 2355 2355
0029 PATCH 2356 2356

Line Notes
0030 MCA 0001 0003

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TERRESTRIAL AND SEA FLOOR MAPPING

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SEATTLE, WA 98107
(206) 420-8304
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Project Information:

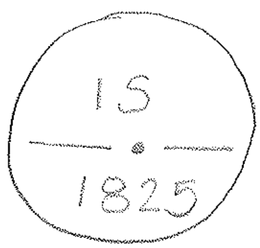
Project Name: 2017-003 MCA Wyckoff
Date: 1/11/17
Project Number: 2017-003
Crew: KM, AS, TY
Location: Eagle Harbor

Coordinate System:

Horizontal Datum:
Coordinate System: WASP 2N NAD83
Units: Ft
Vertical Datum: NAVD88
Units: Ft

Station Information:

Sketch:



Station Name: IS 1825
PID: 5139
Agency: Wash Dot
Monument Type: Aluminum Disk
Setting: Drilling in Concrete
Stamping: IS 1825

Latitude:
Longitude:
Height:
Meas. Northing: 231634.6 usft
Meas. Easting: 1226908.2 usft
Meas. Elevation: 18.3 usft

Description: Aluminum CAP found at ferry terminal Bainbridge Island. Located on concrete walk way to foot traffic for the ferry to Seattle.
6.04 usft ~~2m~~ rod height

Base Station Setup:

Reciever Type/Number:
Antenna Type/Number:

Date	Time	Point No.	Description	HA	Reference

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Project Information:

Project Name: 2017-003 MCA Wyckoff
Date: 1/11/17
Project Number: 2017-003
Crew: KM / AS / TY
Location: Eagle Harbor

Coordinate System:

Horizontal Datum:
Coordinate System: WOSP ZN NAD83
Units: Ft
Vertical Datum: NAVD 88
Units: Ft

Station Information:

Sketch:

Station Name: WIN BM-1
PID:
Agency: WA - DOT
Monument Type: Brass cup
Setting: Concrete Sidewalk
Stamping: WIN BM-1

Latitude:
Longitude:
Height:
meas. Northing: 232042.3 usft
meas. Easting: 1226347.4 usft
meas. Elevation: 48.8

Description: Brass cap found on Sidewalk near ferry terminal.

Base Station Setup:

Reciever Type/Number:
Antenna Type/Number:

Date	Time	Point No.	Description	HA	Reference

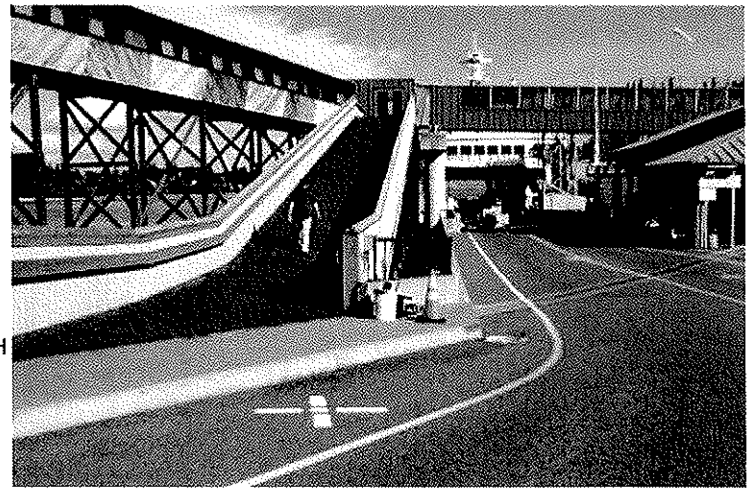
Washington State Department of Transportation

Geographic Services

SURVEY INFORMATION SYSTEM Report of Survey Mark

Designation:	IS1825	**T.R.S:**	25N, 2E, 26	**ACCOUNTS INFORMATION**
Monument ID:	5139	**Corner Code:**		BOOK / PROJECT / INVOICE
NGS Pid:		**State Route:**		177 / XL0903 / 23-01040
State:	WASHINGTON	**Mile Post:**		321 / MS4466 / 23-07029
County:	KITSAP	**Station:**		
Region:	OL	**Offset:**		
Nearest Town:	WINSLOW	**Owner:**	GS	
USGS Quad:	BREMERTON EAST	**Bearing:**	M	

TO REACH THE STATION FROM THE TOLL BOOTHS AT THE WSDOT FERRY TERMINAL IN WINSLOW, GO EASTERLY APPROXIMATELY 100 METERS THROUGH THE VEHICLE LOADING AREA TO MARK ON THE LEFT. IT IS LOCATED IN THE CONCRETE SIDEWALK NEAR THE BASE OF THE PEDESTRIAN RAMP THAT GOES FROM THE LOADING AREA TO THE WOODEN OVERHEAD WALKWAY USED FOR PASSENGER LOADING, 90 CM @ 215 DEGREES FROM A SURVEY MARKER STICKER ON THE EASTERLY POST OF A HENDRAIL SECTION, 34.6 METERS @ 265 DEGREES FROM THE NORTHEAST CORNER OF THE AUTO LOADING RAMP DOCK #1 AND 3.0 METERS @ 130 DEGREES FROM THE APPROXIMATE CENTERLINE OF THE RAMP FOR 'PASSENGER ONLY' LOADING. THE MARK IS AN ALUMINUM SURV CAP CEMENTED INTO A DRILL HOLE AND SET LEVEL WITH THE TOP OF THE CONCRETE SIDEWALK SURFACE.



Survey Control

Datum: NAD 83/07 **Date:** 10/21/2008

Lat: 47 37 21.593595 N **Long:** 122 30 36.897978 W **Ellips:** -17.761 (M) -58.271 (USFt) **Geoid:** -23.327 (M)

Washington State Plane Zone: North

Northing	Easting	Scale	Comb Factor	Conv Angle
70602.360 (M) 231634.576 (USFt)	373962.310 (M) 1226908.012 (USFt)	0.99997938	0.99998217	-1 14 54.6

		Survey Info	Accuracy	Network	Method
Ortho:	Date: 09/19/2001	Horizontal	2 CM	SECONDARY	GPS
Datum:	NAVD 88	Ellips	5 CM		GPS
Elevation:	5.566 (M) 18.261 (USFt)	Ortho	1 CM	PRIMARY	DIFF LEVELS
Mllw: 1983-2001	6.331 (M) 20.77 (USFt)	Mllw	1 CM		DIFF LEVELS

Datum: NAD 83/91			**Date:** 09/19/2001		
Lat: 47 37 21.590581 N	**Long:** 122 30 36.900182 W		**Ellips:** -17.578 (M) -57.670 (USFt)		**Geoid:** -23.144 (M)

Washington State Plane Zone: North				
Northing	**Easting**	**Scale**	**Comb Factor**	**Conv Angle**
70602.268 (M) 231634.274 (USFt)	373962.262 (M) 1226907.855 (USFt)	0.99997938	0.99998214	-1 14 54.6

Ortho:	Date: 09/19/2001	Survey Info	Accuracy	Network	Method
Datum:	NAVD 88	Horizontal	2 CM	SECONDARY	GPS
Elevation:	5.566 (M) 18.261 (USFt)	Ellips	5 CM		GPS
		Ortho	1 CM	PRIMARY	DIFF LEVELS
Mllw: 1983-2001	6.331 (M) 20.77 (USFt)	Mllw	1 CM		DIFF LEVELS

Datum: NAD 83/91			**Date:** 09/19/2001		
Lat: 47 37 21.590581 N	**Long:** 122 30 36.900182 W		**Ellips:** -17.578 (M) -57.670 (USFt)		**Geoid:** -23.144 (M)

Washington State Plane Zone: North				
Northing	**Easting**	**Scale**	**Comb Factor**	**Conv Angle**
70602.268 (M) 231634.274 (USFt)	373962.262 (M) 1226907.855 (USFt)	0.99997938	0.99998214	-1 14 54.6

Ortho:	Date: 09/19/2001	Survey Info	Accuracy	Network	Method
Datum:	NAVD 88	Horizontal	2 CM	SECONDARY	GPS
Elevation:	5.566 (M) 18.261 (USFt)	Ellips	5 CM		GPS
		Ortho	1 CM	PRIMARY	DIFF LEVELS

History

Recovered On	Recovered By	Action	Condition
10/21/2008	GEOGRAPHIC SERVICES	UPDATED	
10/30/2007	GEOGRAPHIC SERVICES	UPDATED	
9/19/2001	GEOGRAPHIC SERVICES	MONUMENTED	

TERRASOND
PRECISION GEOSPATIAL SOLUTIONS

JOB SAFETY ANALYSIS

SMALL BOAT AND TRAILER SAFETY

Department Involved: Survey
Title of Person Doing Job: Project Manager
Person Submitting JSA: Roland Poeckert

Activity Date: 1/11/17
Location of Activity: Eagle Harbor
Supervisor: K. Mildon

Take the time to assess all potential hazards. Be Aware – Be Alert – Communicate

Remember: This JSA deals with potential hazards expected for the activity outlined. Actual activity and circumstances may vary and hazards not identified here may be present. If this is the case, the employee must take appropriate safety measures and document any changes to the basic job steps, potential hazards and steps taken to eliminate or reduce risk.

Safety equipment required to do this job:

☐ Hard Hats	☐ Fire Extinguisher	☐ Work Vest	☐ Dust Mask
☒ Safety Shoes	☐ Safety Glasses w/ Side Shields	☐ Life Rings w/ 90' Floating Line	☐ Back Belts
☐ Hearing Protection	☐ Goggles	☐ Tag Lines	☐ Face Shield
☐ Gloves Type ( )	☐ Safety Harness	☐ Work Permit Required	☐ Floor Mat
☐ Personal Flotation Device (PFD)	☐ Other ( )	☐ Lockout/Tagout	☐ 1st Aid Kit

Comments:

Description of any other job specific hazards:

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommendations to Eliminate or Reduce Potential Hazards
Check boat and secure all equipment on the boat prior to moving	Injury due to slips, trips and falls	Secure any ladders or use a suitable safety ladder for accessing the boat.
	Damage to equipment and other vehicles due to equipment moving and/or falling off boat	Secure all loose equipment using tie downs or stow in an enclosed area.
Check boat and trailer prior to moving	Electrical shock and damage to equipment – boat still connected to electrical outlet (shore power)	Perform a complete walk around inspection to ensure that all electrical connects and lines are safely stored on the boat.
Check tires	Damage to tires and rims if tires not properly inflated	Check tire pressure and correct if necessary.
Check for obstructions	Damage to trailer or boat due to obstructions	Check for and remove any obstructions around and under the trailer. Remove access ladders. Ensure that trailer is hooked up so that it cannot move when chocks are removed. Remove chocks before attempting to move trailer.

Reviewed By:

Name (Print): K. Mildon Signature: [signature] Date: 1/11/17

Name (Print): Andrew Smith Signature: A Smith Date: 1/11/17

Name (Print): Tyler Yost Signature: [signature] Date: 1/11/17

Name (Print): ______ Signature: ______ Date: ______

Name (Print): ______ Signature: ______ Date: ______

Name (Print): ______ Signature: ______ Date: ______

TERRASOND
PRECISION GEOSPATIAL SOLUTIONS

JOB SAFETY ANALYSIS

MAN OVERBOARD RESCUE

Department Involved: Survey
Title of Person Doing Job: Kathleen Mildon
Person Submitting JSA: Roland Poeckert

Activity Date: 1/11/17
Location of Activity: Eagle harbor
Supervisor: K. Mildon

Take the time to assess all potential hazards. Be Aware – Be Alert – Communicate

Remember: This JSA deals with potential hazards expected for the activity outlined. Actual activity and circumstances may vary and hazards not identified here may be present. If this is the case, the employee must take appropriate safety measures and document any changes to the basic job steps, potential hazards and steps taken to eliminate or reduce risk.

Safety equipment required to do this job:

☐ Hard Hats	☐ Fire Extinguisher	☐ Work Vest	☐ Dust Mask
☐ Safety Shoes	☐ Safety Glasses w/ Side Shields	☒ Life Rings w/ 90' Floating Line	☐ Back Belts
☐ Hearing Protection	☐ Goggles	☐ Tag Lines	☐ Face Shield
☐ Gloves Type ( )	☐ Safety Harness	☐ Work Permit Required	☐ Floor Mat
☒ Personal Flotation Device (PFD)	☐ Other ( )	☐ Lockout/Tagout	☒ 1st Aid Kit

Comments:

First Aid behind Captain Seat. Eyes on the person, yell man overboard.

Description of any other job specific hazards:

Sequence of Basic Job Steps	Potential Accidents or Hazards	Recommendations to Eliminate or Reduce Potential Hazards
Raise the alarm.	Personnel going overboard trying to attempt rescue. Rescue lines fouling propellers	Keep the person in sight and deploy safety equipment when it can be reached by the person in the water. Never deploy any equipment without informing the bridge.
The Master is to get a Man Overboard (MOB) Fix. The Master will place an "Urgency" (Pan-Pan) Radio call VHF Channel 16 to Notify the USCG. Alert the Pre-Established Medivac entity including: all other boats in the immediate area.	MOB could be lost at sea. It is imperative to establish communications in work area for immediate assistance.	It is imperative that MOB has immediate fix and is kept in sight. Knowledge of Emergency Communications prior to work.
The spotter should remain on deck, pointing in the direction of the MOB.	Loose sight of person.	Use as many spotters as available.
Spotter should determine if the MOB is conscious or unconscious. MOB should give an "All Well Hand Wave" if he/she is okay. MOB is known to be unconscious.	If MOB is unconscious there could be an immediate drowning situation. There should not be an immediate risk of drowning. Immediate risk of drowning.	All crews should don their work vest properly to be assured that his head will stay out of water. Depending on the circumstances and conditions other vessels in area that are contacted may recover MOB. It may also be possible to retrieve cable and use your own ship as a recovery platform as long as MOB can be kept in sight. Other assist vessels in area could definitely perform a quicker rescue if they are present in the area. If no other vessels are in the area to assist in the recovery, the decision to sever the deep tow cable is imperative.

Reviewed By:

Name (Print): K. Mildon Signature: K Mildon Date: 1/11/17

Name (Print): Andrew Smith Signature: A. Smith Date: 1/11/17

Name (Print): Tyler Yost Signature: [illegible] Date: 1/11/17

Name (Print): ______ Signature: ______ Date: ______

Name (Print): ______ Signature: ______ Date: ______

Name (Print): ______ Signature: ______ Date: ______

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Appendix I-2a. MCA Orthophoto, Lidar, and Bathymetric Survey Report

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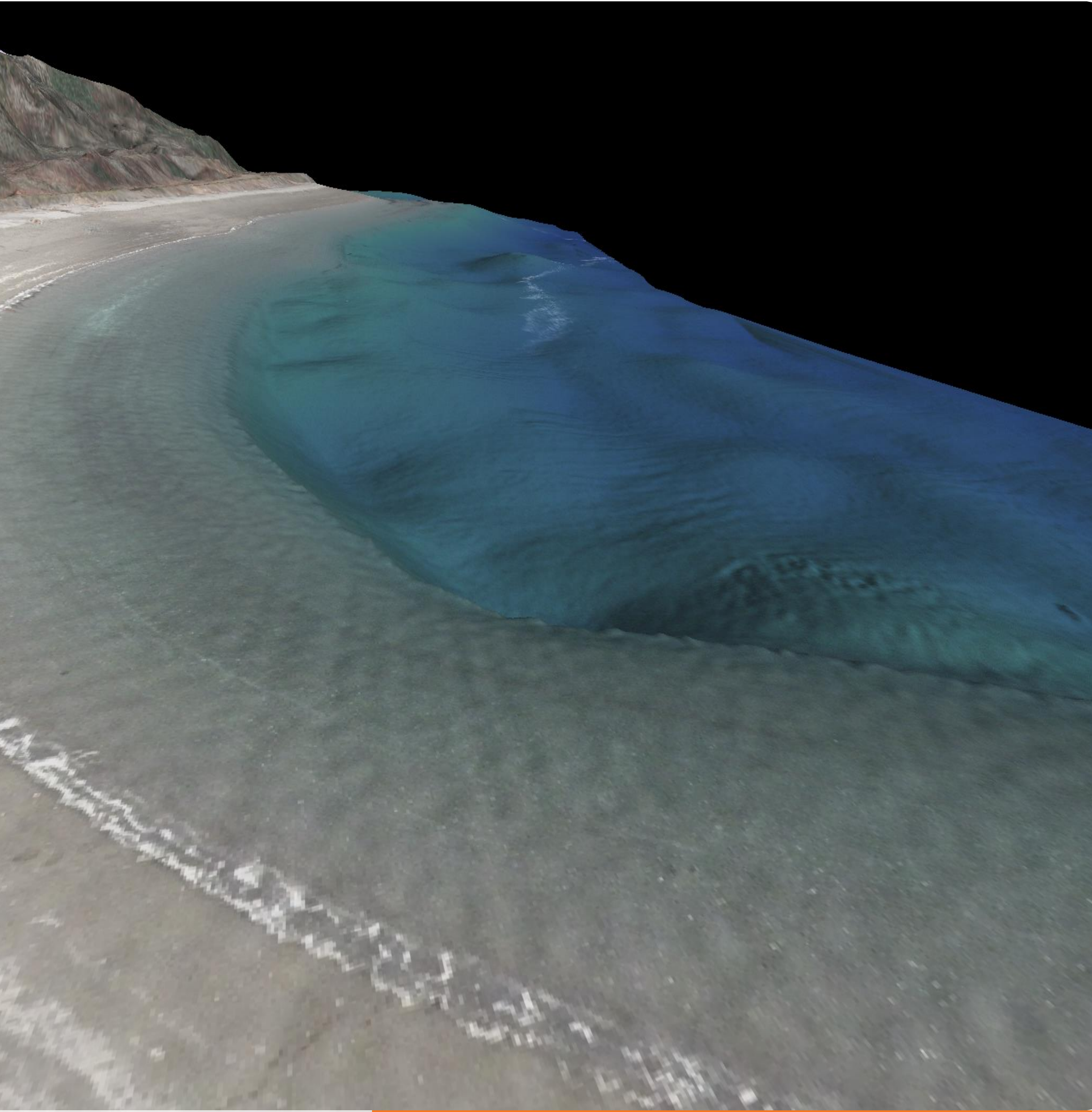

2017 Eagle Harbor

Orthophoto, Lidar and Bathymetric Survey
Project Report

Miller Creek
ASSOCIATES

Contents

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Data Processing 6

Quality Control 6

Deliverables 7

Contact Info 8

Summary

In summer 2017, Miller Creek Associates (MCA) teamed with APS Surveying and Mapping LLC (Ground Survey), Terrasond Ltd (Hydrographic) and Geoterra, Inc (Lidar) to provide mapping data for the Eagle Harbor site in Kitsap County, WA. The Lidar data was acquired with a planned nominal density of 8 points per square meter (PPSM) and was acquired during a -2.6’ MLLW tide. Hydrographic data was acquired during a high tide to ensure sufficient overlap with the lidar data. Imagery was acquired during overcast conditions to ensure minimal shadows.

Lidar Details

Acreage (Lidar/Orthophoto)	36
Flight Date	May 26th, 2017
Coordinate System	Washington State Plane North
Horizontal Datum	NAD83(91)
Vertical Datum	MLLW (NAVD88 + 2.509’)
Unit of Measure	US Survey Foot
Lidar Sensor	Optec Galaxy
Scan Rate	74 Hz
Pulse Rate	350 kHz
Final Point Density (Meters²)	12.29 pts/m²
Field of View (FOV)	30°
Altitude (Feet - AGL)	4900’
RMSEz (Feet)	0.083’

Table 1 - Lidar Details

Orthophoto Details

Acreage (Lidar/Orthophoto)	36
Flight Date	January 30, 2017
Coordinate System	Washington State Plane North
Horizontal Datum	NAD83(91)
Unit of Measure	US Survey Foot
Camera	Ultracam Falcon
Raw Pixel Resolution	.15 Foot
Orthophoto Pixel Resolution	.20 Foot
Final Orthophoto Specifications	8 Bit RGB / 8 Bit CIR
Overlap / Sidelap	60 / 45
Flight Altitude (Feet - AGL)	2000
Camera	Ultracam Falcon

Table 2 - Orthophoto Details

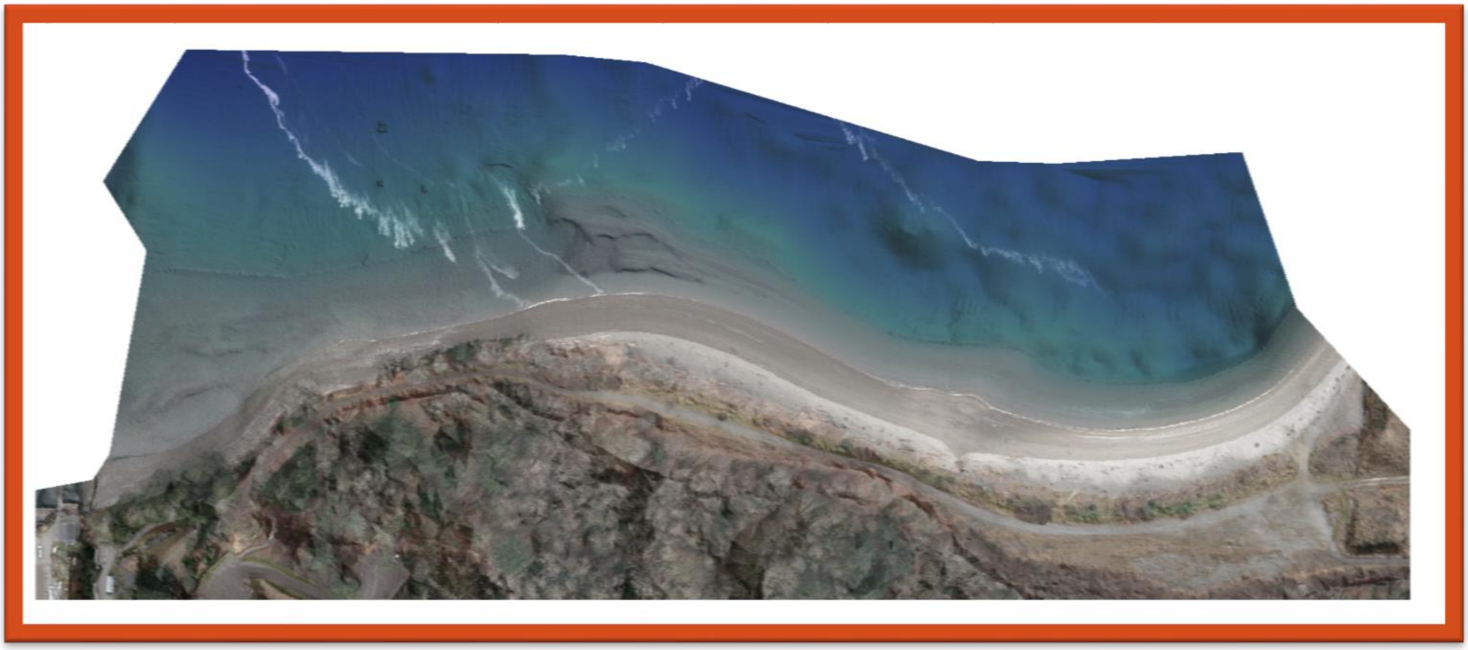

Figure 1 – Ortho/Terrain view

Lidar Acquisition

All lidar data was acquired on May 26th, 2017 during a single mission. The sensor used was an Optech Galaxy mounted in Cessna 310 fixed-wing aircraft. The flight plan was designed with a minimum of 50% overlap in swath footprint to minimize laser shadowing and data gaps. Flight planning was performed using Optech Flight Management System (FMS) software to calculate optimum parameters to meet project requirements and accommodate terrain variations. Airborne GPS and IMU data were acquired during flight to ensure a tight relative fit and geo-reference the data. Data was acquired at a -2.6' tide to ensure significant overlap between the lidar and hydrographic data.

Hydrographic Data Acquisition

For details on the hydrographic mission, see *2017_EagleHarbor_HydrographicSurvey_Report.pdf*

Image Acquisition

Image acquisition of was performed on January 30, 2017 using a gyro-stabilized Ultracam Falcon digital image sensor mounted in a Cessna 206 StationAir. Imagery was acquired under high-overcast conditions to minimize shadows. Image sidelap for the project was increased to 45% from the industry standard of 30%. This increased overlap serves to reduce the lean of trees and buildings and improves accuracy overall.

Survey Report

After a tight relative fit was achieved, an absolute vertical offset was calculated using surveyed control points. MCA was provided with 57 ground control points. Of the 57 points, 40 of those were determined to be appropriate as vertical control points to be used to provide an absolute vertical offset for the final point cloud. Final RMSE on the points used for the vertical offset was .083’. Additionally, 9 ground control points were used in the aerotriagulation process to georeference the imagery.

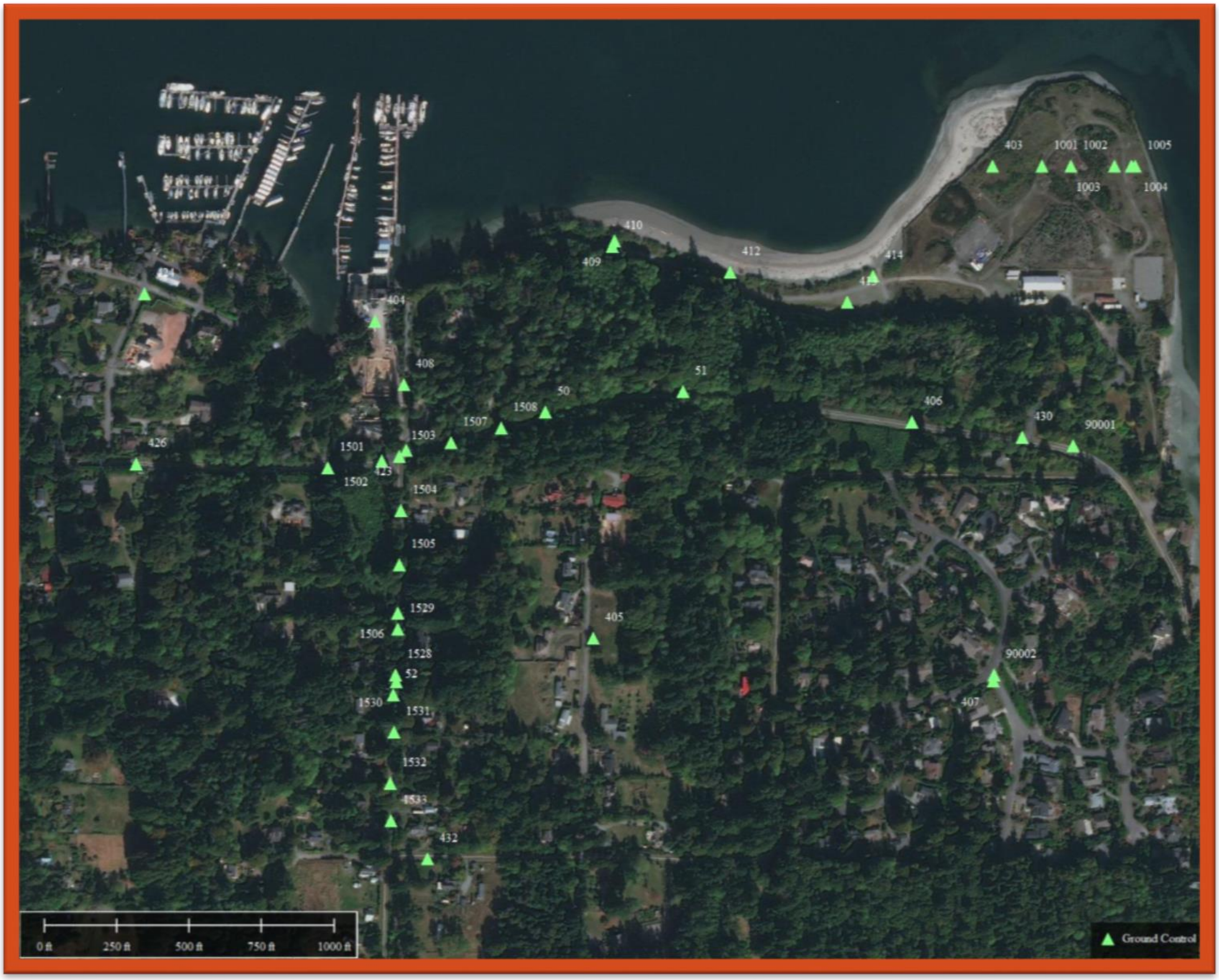

Figure 3 – Survey control distribution

Survey Control

Point #	X	Y	Z	Dz*
410	1227556.551	229261.435	18.955	-0.151
1005	1229360.281	229537.828	18.049	-0.123
1001	1229039.518	229537.771	15.283	-0.115
413	1228367.065	229070.954	16.842	-0.113
1003	1229288.135	229537.757	15.168	-0.106
1532	1226790.120	227417.075	135.088	-0.104
1004	1229347.467	229537.682	15.749	-0.103
1533	1226792.721	227290.003	137.901	-0.102
50	1227327.281	228693.994	85.726	-0.096
1002	1229139.629	229537.807	13.877	-0.093
414	1228456.920	229160.290	17.910	-0.072
90001	1229148.016	228577.166	94.172	-0.051
1528	1226808.885	227789.366	114.407	-0.045
1530	1226812.749	227765.554	116.138	-0.035
52	1226801.238	227723.067	118.636	-0.025
408	1226839.121	228787.858	37.251	-0.023
1529	1226817.647	227947.138	100.195	-0.004
424	1225944.297	229099.173	44.505	0.001
403	1228868.774	229537.751	22.786	0.011
1504	1226826.600	228353.305	66.380	0.011
1508	1227174.487	228636.833	77.507	0.013
90002	1228873.734	227791.020	204.680	0.014
1503	1226823.843	228539.710	59.002	0.016
423	1226847.058	228561.782	58.462	0.017
430	1228970.743	228605.379	101.754	0.017
405	1227491.554	227916.866	191.850	0.017
406	1228592.213	228659.863	96.939	0.018
407	1228871.527	227769.831	205.819	0.024
1502	1226761.383	228524.860	58.727	0.032
1501	1226576.613	228502.178	65.988	0.035
1507	1227000.206	228587.509	67.818	0.038
51	1227801.480	228762.725	100.061	0.040
1506	1226818.687	228001.738	94.670	0.046
409	1227564.388	229280.907	18.974	0.095
432	1226919.195	227158.313	151.479	0.101
412	1227964.443	229173.690	17.391	0.117
1531	1226804.013	227593.020	125.120	0.125
404	1226739.411	229006.074	20.364	0.133
426	1225913.796	228513.325	98.453	0.163
1505	1226822.462	228168.323	76.936	0.184

Table 3 – Survey Control values

* This value represents the difference between the value of the ground control and the value of the lidar.

Lidar Data Processing

After primary data acquisition, the raw data is calibrated. This process includes relative adjustments between flight strips using common planes. Automatic point cloud classification was performed and significant water bodies were outlined for classification as water.

After initial point cloud calibration and geo-referencing, the TerraSolid software suite was used for automated point cloud classification. This process uses complex algorithms to analyze the point cloud and metadata, and classify ground, non-ground and anomalous high and low points. All tiles were edited manually to identify areas where the automated classification was insufficient, or where man-made structures require manual reclassification.

Lidar Quality Control

MCA performed a comprehensive quality control assessment of the data. All datasets were checked against each other for consistency, accuracy and completeness. Specific quality control checks included the following:

1. Point cloud data checked against survey checkpoints for absolute accuracy
2. Inspection of all deliverables for completeness and accuracy
    a. Map projection check
    b. Data completeness check
    c. Generation of shaded relief for visual QC

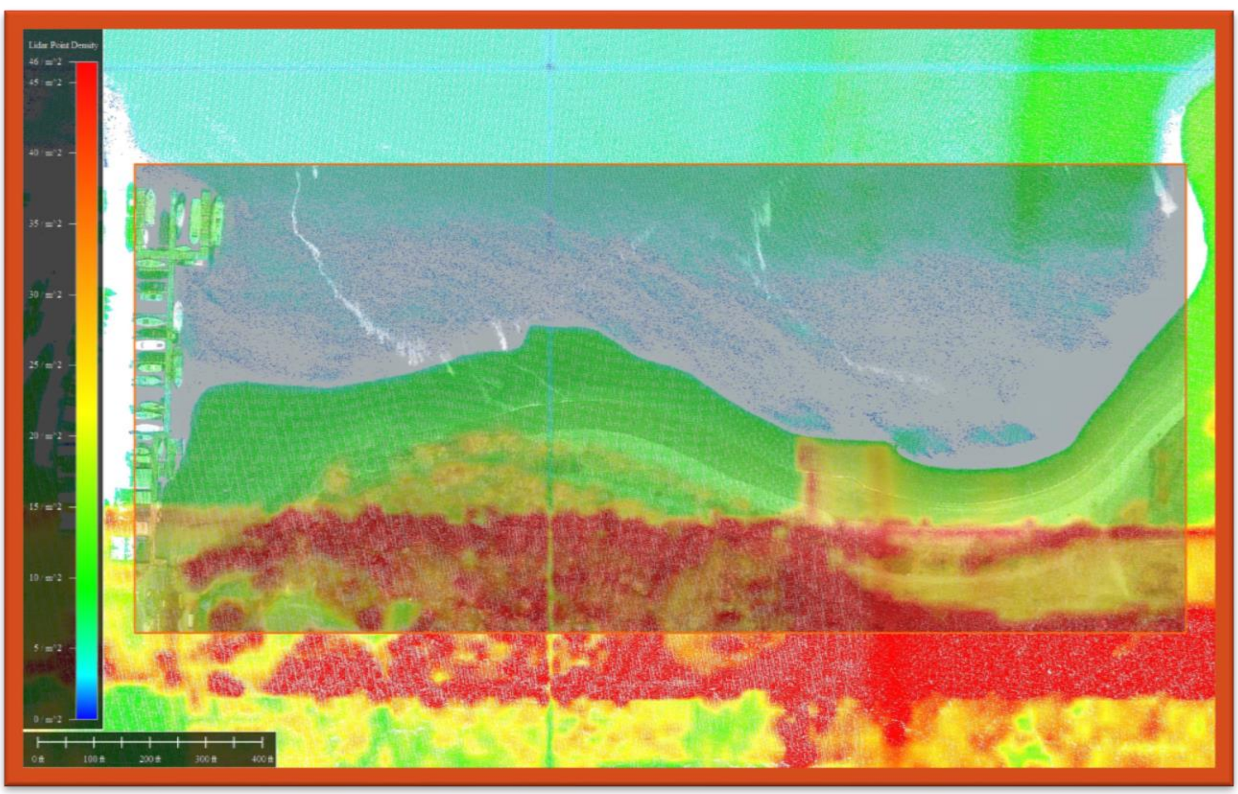

Figure 3 – First return point density in points per m² (PPSM)

Lidar Classifications

Class	Description
1	Non-Ground
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Noise
9	Water

Table 4 – Lidar Classifications

Deliverables

Lidar

All returns	LAS 1.2
Bare Earth	LAS 1.2
DEM (1ft)	ESRI
Lidar/Ortho Project Report	PFD

Orthophoto

Natural Color RGB Orthophoto	TIFF/SID Mosaic
FCIR Orthophoto	TIFF/SID Mosaic
Tile Layout	Shape

Hydrographic

ASCii Point	TXT
DEM (1ft and 3ft)	ESRI
Hill Shade Imagery	TIFF
Hydrographic Project Report	PFD

Table 5 - Deliverables

Contact Info

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